

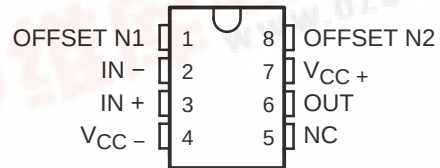
# TLE2027-Q1, TLE2037-Q1, TLE2027A-Q1, TLE2037A-Q1 EXCALIBUR LOW-NOISE HIGH-SPEED PRECISION OPERATIONAL AMPLIFIERS

查询"TLE2037-Q1"供应商

SGLS202B – OCTOBER 2003 – REVISED APRIL 2008

- Qualified for Automotive Applications
- ESD Protection Exceeds 2000 V Per MIL-STD-883, Method 3015; Exceeds 200 V Using Machine Model (C = 200 pF, R = 0)
- Outstanding Combination of DC Precision and AC Performance:
  - Unity-Gain Bandwidth . . . 15 MHz Typ
  - $V_n$  . . . . 3.3 nV/ $\sqrt{\text{Hz}}$  at  $f = 10$  Hz Typ,  
2.5 nV/ $\sqrt{\text{Hz}}$  at  $f = 1$  kHz Typ
  - $V_{IO}$  . . . . 25  $\mu\text{V}$  Max
  - $A_{VD}$  . . . 45 V/ $\mu\text{V}$  Typ With  $R_L = 2$  k $\Omega$ ,  
19 V/ $\mu\text{V}$  Typ With  $R_L = 600$   $\Omega$
- Available in Standard-Pinout Small-Outline Package
- Output Features Saturation Recovery Circuitry
- Macromodels and Statistical information

D PACKAGE  
(TOP VIEW)



## description

The TLE20x7 and TLE20x7A contain innovative circuit design expertise and high-quality process control techniques to produce a level of ac performance and dc precision previously unavailable in single operational amplifiers. Manufactured using Texas Instruments state-of-the-art Excalibur process, these devices allow upgrades to systems that use lower-precision devices.

In the area of dc precision, the TLE20x7 and TLE20x7A offer maximum offset voltages of 100  $\mu\text{V}$  and 25  $\mu\text{V}$ , respectively, common-mode rejection ratio of 131 dB (typ), supply voltage rejection ratio of 144 dB (typ), and dc gain of 45 V/ $\mu\text{V}$  (typ).

The ac performance of the TLE2027 and TLE2037 is highlighted by a typical unity-gain bandwidth specification of 15 MHz, 55° of phase margin, and noise voltage specifications of 3.3 nV/ $\sqrt{\text{Hz}}$  and 2.5 nV/ $\sqrt{\text{Hz}}$  at frequencies of 10 Hz and 1 kHz, respectively. The TLE2037 and TLE2037A have been decompensated for faster slew rate ( $\sim 7.5$  V/ $\mu\text{s}$ , typical) and wider bandwidth (50 MHz). To ensure stability, the TLE2037 and TLE2037A should be operated with a closed-loop gain of 5 or greater.

## ORDERING INFORMATION†

| $T_A$          | $V_{IO\text{max}}$<br>AT 25°C | PACKAGE‡ |               | ORDERABLE<br>PART NUMBER | TOP-SIDE<br>MARKING |
|----------------|-------------------------------|----------|---------------|--------------------------|---------------------|
| –40°C to 125°C | 25 $\mu\text{V}$              | SOIC (D) | Tape and reel | TLE2027AQDRQ1            | 2027AQ              |
|                |                               |          |               | TLE2037AQDRQ1            | 2037AQ              |
|                | 100 $\mu\text{V}$             | SOIC (D) | Tape and reel | TLE2027QDRQ1             | 2027Q1              |
|                |                               |          |               | TLE2037QDRQ1             | 2037Q1              |

† For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at <http://www.ti.com>.

‡ Package drawings, thermal data, and symbolization are available at <http://www.ti.com/packaging>.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

**TEXAS  
INSTRUMENTS**

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# TLE2027-Q1, TLE2037-Q1, TLE2027A-Q1, TLE2037A-Q1 EXCALIBUR LOW-NOISE HIGH-SPEED PRECISION OPERATIONAL AMPLIFIERS

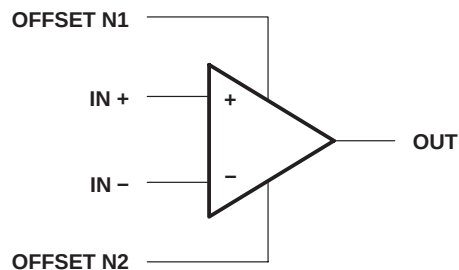
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## description (continued)

Both the TLE20x7 and TLE20x7A are available in a wide variety of packages, including the industry-standard 8-pin small-outline version for high-density system applications. The Q-suffix devices are characterized for operation from  $-40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ .

## symbol

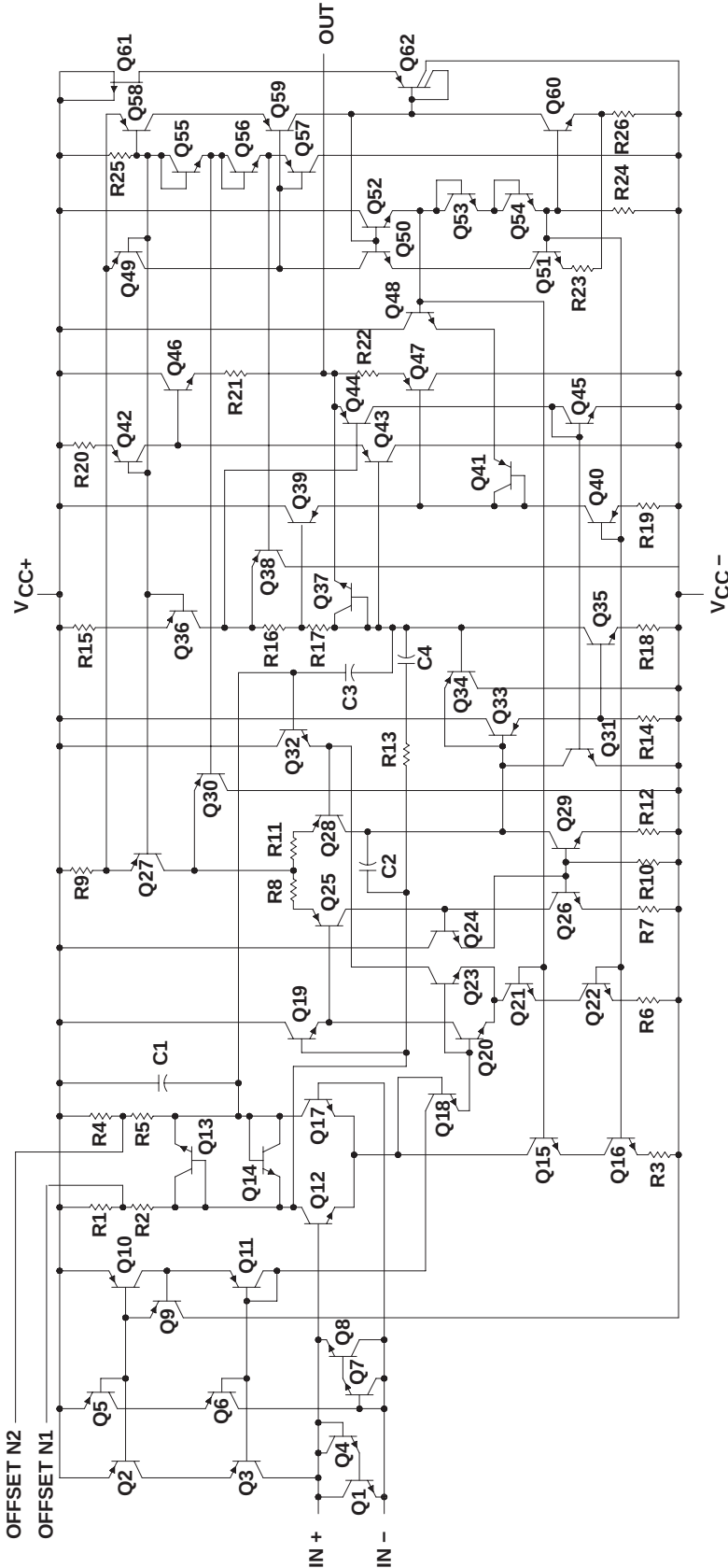


TLE2027-Q1, TLE2037-Q1, TLE2027A-Q1, TLE2037A-Q1  
EXCALIBUR LOW-NOISE HIGH-SPEED  
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equivalent schematic



| ACTUAL DEVICE COMPONENT COUNT |         |         |  |
|-------------------------------|---------|---------|--|
| COMPONENT                     | TLE2027 | TLE2037 |  |
| Transistors                   | 61      | 61      |  |
| Resistors                     | 26      | 26      |  |
| epiFET                        | 1       | 1       |  |
| Capacitors                    | 4       | 4       |  |

TLE2027-Q1, TLE2037-Q1, TLE2027A-Q1, TLE2037A-Q1  
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absolute maximum ratings over operating free-air temperature range (unless otherwise noted)<sup>†</sup>

|                                                                            |                |
|----------------------------------------------------------------------------|----------------|
| Supply voltage, $V_{CC+}$ (see Note 1)                                     | 19 V           |
| Supply voltage, $V_{CC-}$                                                  | -19 V          |
| Differential input voltage, $V_{ID}$ (see Note 2)                          | $\pm 1.2$ V    |
| Input voltage range, $V_I$ (any input)                                     | $V_{CC\pm}$    |
| Input current, $I_I$ (each input)                                          | $\pm 1$ mA     |
| Output current, $I_O$                                                      | $\pm 50$ mA    |
| Total current into $V_{CC+}$                                               | 50 mA          |
| Total current out of $V_{CC-}$                                             | 50 mA          |
| Duration of short-circuit current at (or below) 25°C (see Note 3)          | Unlimited      |
| Junction temperature, $T_J$                                                | 142°C          |
| Operating free-air temperature range, $T_A$ : Q suffix                     | -40°C to 125°C |
| Storage temperature range, $T_{stg}$                                       | -65°C to 150°C |
| Package thermal impedance, $\theta_{JA}$ (D Package) (0 LFPM) (see Note 4) | 101°C/W        |
| Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: D package    | 260°C          |

<sup>†</sup> Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

- NOTES:
1. All voltage values, except differential voltages, are with respect to the midpoint between  $V_{CC+}$  and  $V_{CC-}$ .
  2. Differential voltages are at  $IN+$  with respect to  $IN-$ . Excessive current flows if a differential input voltage in excess of approximately  $\pm 1.2$  V is applied between the inputs, unless some limiting resistance is used.
  3. The output may be shorted to either supply. Temperature and/or supply voltages must be limited to ensure that the maximum dissipation rating is not exceeded.
  4. The thermal impedance is calculated in accordance with JESD 51-7.

recommended operating conditions

|                                       |                                    | MIN     | MAX      | UNIT |
|---------------------------------------|------------------------------------|---------|----------|------|
| Supply voltage, $V_{CC\pm}$           |                                    | $\pm 4$ | $\pm 19$ | V    |
| Common-mode input voltage, $V_{IC}$   | $T_A = 25^\circ\text{C}$           | -11     | 11       | V    |
|                                       | $T_A = \text{Full range}^\ddagger$ | -10.2   | 10.2     |      |
| Operating free-air temperature, $T_A$ |                                    | -40     | 125      | °C   |

<sup>‡</sup> Full range is -40°C to 125°C for Q-suffix devices.



**TLE2027-Q1, TLE2037-Q1, TLE2027A-Q1, TLE2037A-Q1**  
**EXCALIBUR LOW-NOISE HIGH-SPEED**  
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**TLE20x7-Q1 electrical characteristics at specified free-air temperature,  $V_{CC\pm} = \pm 15$  V (unless otherwise noted)**

| PARAMETER         |                                                                       | TEST CONDITIONS                                                  | T <sub>A</sub> <sup>†</sup> | TLE20x7-Q1    |           |               | TLE20x7A-Q1 |       |     | UNIT |
|-------------------|-----------------------------------------------------------------------|------------------------------------------------------------------|-----------------------------|---------------|-----------|---------------|-------------|-------|-----|------|
|                   |                                                                       |                                                                  |                             | MIN           | TYP       | MAX           | MIN         | TYP   | MAX |      |
| V <sub>IO</sub>   | Input offset voltage                                                  | V <sub>IC</sub> = 0,    R <sub>S</sub> = 50 Ω                    | 25°C                        | 20            | 100       | 10            | 25          | μV    |     |      |
|                   |                                                                       |                                                                  | Full range                  | 200           |           |               | 105         |       |     |      |
| α <sub>VIO</sub>  | Temperature coefficient of input offset voltage                       |                                                                  | Full range                  | 0.4           |           |               | 1           | μV/°C |     |      |
|                   | Input offset voltage long-term drift (see Note 4)                     |                                                                  | 25°C                        | 0.006         |           |               | 1           | μV/mo |     |      |
| I <sub>IO</sub>   | Input offset current                                                  |                                                                  | 25°C                        | 6             | 90        | 6             | 90          | nA    |     |      |
|                   |                                                                       |                                                                  | Full range                  | 150           |           |               | 150         |       |     |      |
| I <sub>IB</sub>   | Input bias current                                                    |                                                                  | 25°C                        | 15            | 90        | 15            | 90          | nA    |     |      |
|                   |                                                                       |                                                                  | Full range                  | 150           |           |               | 150         |       |     |      |
| V <sub>ICR</sub>  | Common-mode input voltage range                                       | R <sub>S</sub> = 50 Ω                                            | 25°C                        | -11 to 11     | -13 to 13 | -11 to 11     | -13 to 13   | V     |     |      |
|                   |                                                                       |                                                                  | Full range                  | -10.3 to 10.3 |           | -10.4 to 10.4 |             |       |     |      |
| V <sub>OM</sub> + | Maximum positive peak output voltage swing                            | R <sub>L</sub> = 600 Ω                                           | 25°C                        | 10.5          | 12.9      | 10.5          | 12.9        | V     |     |      |
|                   |                                                                       |                                                                  | Full range                  | 10            |           | 10            |             |       |     |      |
|                   |                                                                       | R <sub>L</sub> = 2 kΩ                                            | 25°C                        | 12            | 13.2      | 12            | 13.2        |       |     |      |
|                   |                                                                       |                                                                  | Full range                  | 11            |           | 11            |             |       |     |      |
| V <sub>OM</sub> - | Maximum negative peak output voltage swing                            | R <sub>L</sub> = 600 Ω                                           | 25°C                        | -10.5         | -13       | -10.5         | -13         | V     |     |      |
|                   |                                                                       |                                                                  | Full range                  | -10           |           | -10           |             |       |     |      |
|                   |                                                                       | R <sub>L</sub> = 2 kΩ                                            | 25°C                        | -12           | -13.5     | -12           | -13.5       |       |     |      |
|                   |                                                                       |                                                                  | Full range                  | -11           |           | -11           |             |       |     |      |
| A <sub>VD</sub>   | Large-signal differential voltage amplification                       | V <sub>O</sub> = ±11 V, R <sub>L</sub> = 2 kΩ                    | 25°C                        | 5             | 45        | 10            | 45          | V/μV  |     |      |
|                   |                                                                       | V <sub>O</sub> = ±10 V, R <sub>L</sub> = 2 kΩ                    | Full range                  | 2.5           |           | 3.5           |             |       |     |      |
|                   |                                                                       | V <sub>O</sub> = ±10 V, R <sub>L</sub> = 1 kΩ                    | 25°C                        | 3.5           | 38        | 8             | 38          |       |     |      |
|                   |                                                                       |                                                                  | Full range                  | 1.8           |           | 2.2           |             |       |     |      |
|                   |                                                                       | V <sub>O</sub> = ±10 V, R <sub>L</sub> = 600 Ω                   | 25°C                        | 2             | 19        | 5             | 19          |       |     |      |
| C <sub>i</sub>    | Input capacitance                                                     |                                                                  | 25°C                        | 8             |           |               | 8           |       | pF  |      |
| z <sub>o</sub>    | Open-loop output impedance                                            | I <sub>O</sub> = 0                                               | 25°C                        | 50            |           |               | 50          |       | Ω   |      |
| CMRR              | Common-mode rejection ratio                                           | V <sub>IC</sub> = V <sub>ICRmin</sub> ,<br>R <sub>S</sub> = 50 Ω | 25°C                        | 100           | 131       | 117           | 131         | dB    |     |      |
|                   |                                                                       |                                                                  | Full range                  | 96            |           |               | 113         |       |     |      |
| k <sub>SVR</sub>  | Supply-voltage rejection ratio (ΔV <sub>CC±</sub> /ΔV <sub>IO</sub> ) | V <sub>CC±</sub> = ±4 V to ±18 V,<br>R <sub>S</sub> = 50 Ω       | 25°C                        | 94            | 144       | 110           | 144         | dB    |     |      |
|                   |                                                                       | V <sub>CC±</sub> = ±4 V to ±18 V,<br>R <sub>S</sub> = 50 Ω       | Full range                  | 90            |           |               | 105         |       |     |      |
| I <sub>CC</sub>   | Supply current                                                        | V <sub>O</sub> = 0,    No load                                   | 25°C                        | 3.8           | 5.3       | 3.8           | 5.3         | mA    |     |      |
|                   |                                                                       |                                                                  | Full range                  | 5.6           |           |               | 5.6         |       |     |      |

$^\dagger$  Full range is  $-40^\circ C$  to  $125^\circ C$ .

NOTE 4: Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at  $T_A = 150^\circ C$  extrapolated to  $T_A = 25^\circ C$  using the Arrhenius equation and assuming an activation energy of 0.96 eV.



# TLE2027-Q1, TLE2037-Q1, TLE2027A-Q1, TLE2037A-Q1

## EXCALIBUR LOW-NOISE HIGH-SPEED PRECISION OPERATIONAL AMPLIFIERS

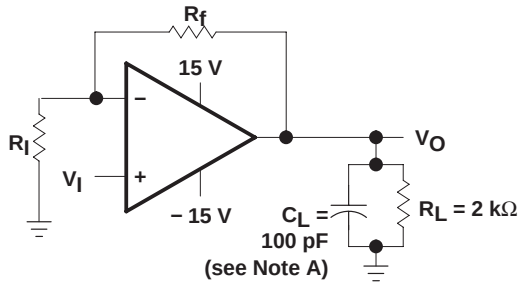
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TLE20x7-Q1 operating characteristics at specified free-air temperature,  $V_{CC \pm} = \pm 15\text{ V}$ ,  $T_A = 25^\circ\text{C}$  (unless otherwise specified)

| PARAMETER          |                                               | TEST CONDITIONS                                                                                        |         | TLE20x7-Q1 |     |     | TLE20x7A-Q1 |     |        | UNIT |
|--------------------|-----------------------------------------------|--------------------------------------------------------------------------------------------------------|---------|------------|-----|-----|-------------|-----|--------|------|
|                    |                                               |                                                                                                        |         | MIN        | TYP | MAX | MIN         | TYP | MAX    |      |
| SR                 | Slew rate at unity gain                       | R <sub>L</sub> = 2 kΩ,<br>C <sub>L</sub> = 100 pF,<br>See Figure 1                                     | TLE2027 | 1.7        | 2.8 |     | 1.7         | 2.8 |        | V/μs |
|                    |                                               |                                                                                                        | TLE2037 | 6          | 7.5 |     | 6           | 7.5 |        |      |
|                    |                                               | R <sub>L</sub> = 2 kΩ,<br>C <sub>L</sub> = 100 pF,<br>T <sub>A</sub> = −55°C to 125°C,<br>See Figure 1 | TLE2027 | 1          |     |     | 1           |     |        |      |
|                    |                                               |                                                                                                        | TLE2037 | 4.4        |     |     | 4.4         |     |        |      |
| V <sub>n</sub>     | Equivalent input noise voltage (see Figure 2) | R <sub>S</sub> = 20 Ω, f = 10 Hz                                                                       |         | 3.3        | 8   |     | 3.3         | 4.5 | nV/√Hz |      |
|                    |                                               | R <sub>S</sub> = 20 Ω, f = 1 kHz                                                                       |         | 2.5        | 4.5 |     | 2.5         | 3.8 |        |      |
| V <sub>N(PP)</sub> | Peak-to-peak equivalent input noise voltage   | f = 0.1 Hz to 10 Hz                                                                                    |         | 50         | 250 |     | 50          | 130 | nV     |      |
| I <sub>n</sub>     | Equivalent input noise current                | f = 10 Hz                                                                                              |         | 10         |     |     | 10          |     | pA/√Hz |      |
|                    |                                               | f = 1 kHz                                                                                              |         | 0.8        |     |     | 0.8         |     |        |      |
| THD                | Total harmonic distortion                     | V <sub>O</sub> = +10 V,<br>A <sub>VD</sub> = 1,<br>See Note 5                                          | TLE2027 | <0.002     |     |     | <0.002      |     | %      |      |
|                    |                                               | V <sub>O</sub> = +10 V,<br>A <sub>VD</sub> = 5,<br>See Note 5                                          | TLE2037 | <0.002     |     |     | <0.002      |     |        |      |
| B <sub>1</sub>     | Unity-gain bandwidth (see Figure 3)           | R <sub>L</sub> = 2 kΩ,<br>C <sub>L</sub> = 100 pF                                                      | TLE2027 | 7          | 13  |     | 9           | 13  | MHz    |      |
|                    |                                               |                                                                                                        | TLE2037 | 35         | 50  |     | 35          | 50  |        |      |
| B <sub>OM</sub>    | Maximum output-swing bandwidth                | R <sub>L</sub> = 2 kΩ                                                                                  | TLE2027 | 30         |     |     | 30          |     | kHz    |      |
|                    |                                               |                                                                                                        | TLE2037 | 80         |     |     | 80          |     |        |      |
| ϕ <sub>m</sub>     | Phase margin at unity gain (see Figure 3)     | R <sub>L</sub> = 2 kΩ,<br>C <sub>L</sub> = 100 pF                                                      | TLE2027 | 55         |     |     | 55          |     | °      |      |
|                    |                                               |                                                                                                        | TLE2037 | 50         |     |     | 50          |     |        |      |

NOTE 5: Measured distortion of the source used in the analysis was 0.002%.

## PARAMETER MEASUREMENT INFORMATION



NOTE A:  $C_L$  includes fixture capacitance.

Figure 1. Slew-Rate Test Circuit

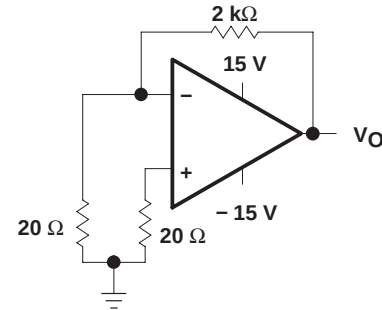
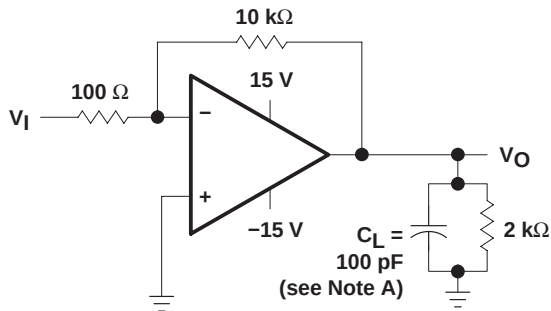
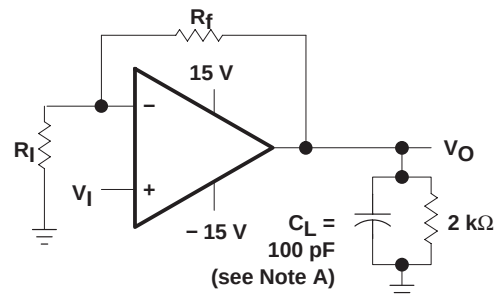


Figure 2. Noise-Voltage Test Circuit



NOTE A:  $C_L$  includes fixture capacitance.

Figure 3. Unity-Gain Bandwidth and Phase-Margin Test Circuit (TLE2027 Only)



NOTES: A.  $C_L$  includes fixture capacitance.  
B. For the TLE2037 and TLE2037A,  $A_{VD}$  must be  $\geq 5$ .

Figure 4. Small-Signal Pulse-Response Test Circuit

# TLE2027-Q1, TLE2037-Q1, TLE2027A-Q1, TLE2037A-Q1 EXCALIBUR LOW-NOISE HIGH-SPEED PRECISION OPERATIONAL AMPLIFIERS

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## typical values

Typical values presented in this data sheet represent the median (50% point) of device parametric performance.

## initial estimates of parameter distributions

In the ongoing program of improving data sheets and supplying more information to our customers, Texas Instruments has added an estimate of not only the typical values, but also the spread around these values. These are in the form of distribution bars that show the 95% (upper) points and the 5% (lower) points from the characterization of the initial wafer lots of this new device type (see Figure 5). The distribution bars are shown at the points where data was actually collected. The 95% and 5% points are used instead of  $\pm 3$  sigma, since some of the distributions are not true Gaussian distributions.

The number of units tested and the number of different wafer lots used are on all of the graphs where distribution bars are shown. As noted in Figure 5, there were a total of 835 units from two wafer lots. In this case, there is a good estimate for the within-lot variability and a possibly poor estimate of the lot-to-lot variability. This is always the case on newly released products, since there can only be data available from a few wafer lots.

The distribution bars are not intended to replace the minimum and maximum limits in the electrical tables. Each distribution bar represents 90% of the total units tested at a specific temperature. While 10% of the units tested fell outside any given distribution bar, this should not be interpreted to mean that the same individual devices fell outside every distribution bar.

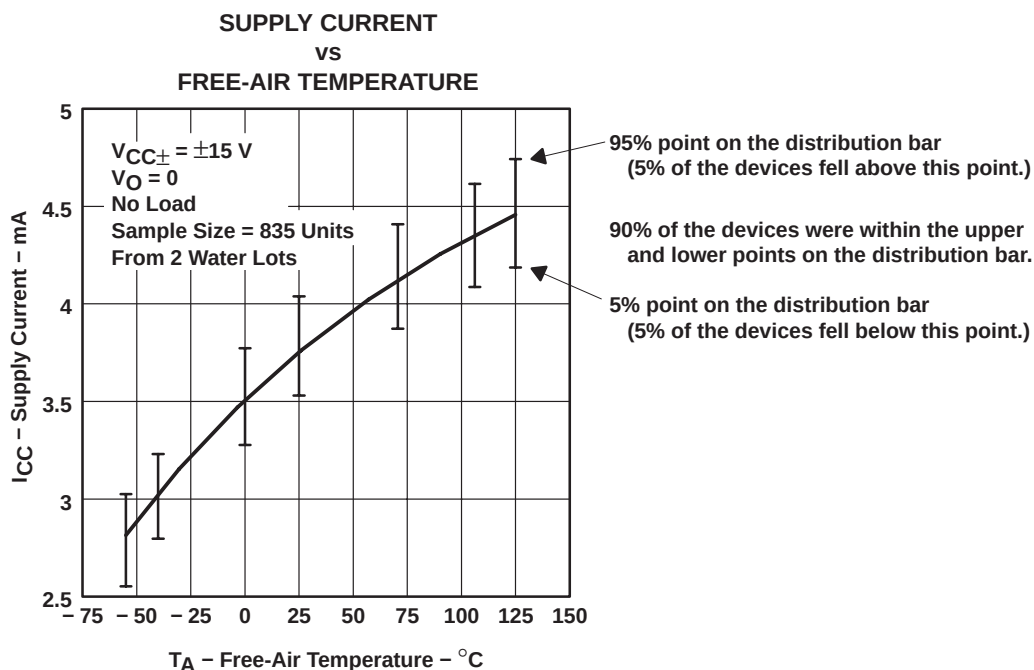


Figure 5. Sample Graph With Distribution Bars



**TLE2027-Q1, TLE2037-Q1, TLE2027A-Q1, TLE2037A-Q1**  
**EXCALIBUR LOW-NOISE HIGH-SPEED**  
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**TYPICAL CHARACTERISTICS**

**Table of Graphs**

|                 |                                                 |                               | FIGURE  |
|-----------------|-------------------------------------------------|-------------------------------|---------|
| $V_{IO}$        | Input offset voltage                            | Distribution                  | 6, 7    |
| $\Delta V_{IO}$ | Input offset voltage change                     | vs Time after power on        | 8, 9    |
| $I_{IO}$        | Input offset current                            | vs Free-air temperature       | 10      |
| $I_{IB}$        | Input bias current                              | vs Free-air temperature       | 11      |
|                 |                                                 | vs Common-mode input voltage  | 12      |
| $I_I$           | Input current                                   | vs Differential input voltage | 13      |
| $V_{O(PP)}$     | Maximum peak-to-peak output voltage             | vs Frequency                  | 14, 15  |
| $V_{OM}$        | Maximum (positive/negative) peak output voltage | vs Load resistance            | 16, 17  |
|                 |                                                 | vs Free-air temperature       | 18, 19  |
| $A_{VD}$        | Large-signal differential voltage amplification | vs Supply voltage             | 20      |
|                 |                                                 | vs Load resistance            | 21      |
|                 |                                                 | vs Frequency                  | 22 – 25 |
|                 |                                                 | vs Free-air temperature       | 26      |
| $z_o$           | Output impedance                                | vs Frequency                  | 27      |
| CMRR            | Common-mode rejection ratio                     | vs Frequency                  | 28      |
| $k_{SVR}$       | Supply-voltage rejection ratio                  | vs Frequency                  | 29      |
| $I_{OS}$        | Short-circuit output current                    | vs Supply voltage             | 30, 31  |
|                 |                                                 | vs Elapsed time               | 32, 33  |
|                 |                                                 | vs Free-air temperature       | 34, 35  |
| $I_{CC}$        | Supply current                                  | vs Supply voltage             | 36      |
|                 |                                                 | vs Free-air temperature       | 37      |
|                 | Voltage-follower pulse response                 | Small signal                  | 38, 40  |
|                 |                                                 | Large signal                  | 39, 41  |
| $V_n$           | Equivalent input noise voltage                  | vs Frequency                  | 42      |
|                 | Noise voltage (referred to input)               | Over 10-second interval       | 43      |
| $B_1$           | Unity-gain bandwidth                            | vs Supply voltage             | 44      |
|                 |                                                 | vs Load capacitance           | 45      |
|                 | Gain bandwidth product                          | vs Supply voltage             | 46      |
|                 |                                                 | vs Load capacitance           | 47      |
| SR              | Slew rate                                       | vs Free-air temperature       | 48, 49  |
| $\phi_m$        | Phase margin                                    | vs Supply voltage             | 50, 51  |
|                 |                                                 | vs Load capacitance           | 52, 53  |
|                 |                                                 | vs Free-air temperature       | 54, 55  |
|                 | Phase shift                                     | vs Frequency                  | 22 – 25 |



# TLE2027-Q1, TLE2037-Q1, TLE2027A-Q1, TLE2037A-Q1 EXCALIBUR LOW-NOISE HIGH-SPEED PRECISION OPERATIONAL AMPLIFIERS

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## TYPICAL CHARACTERISTICS

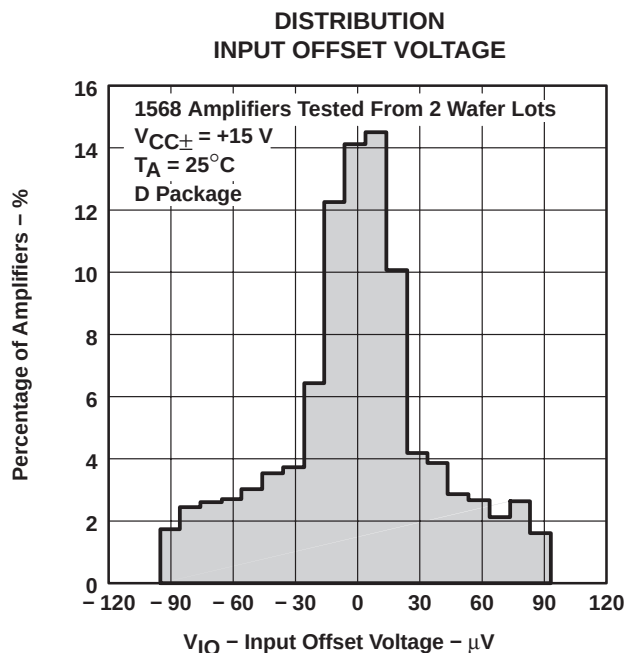


Figure 6

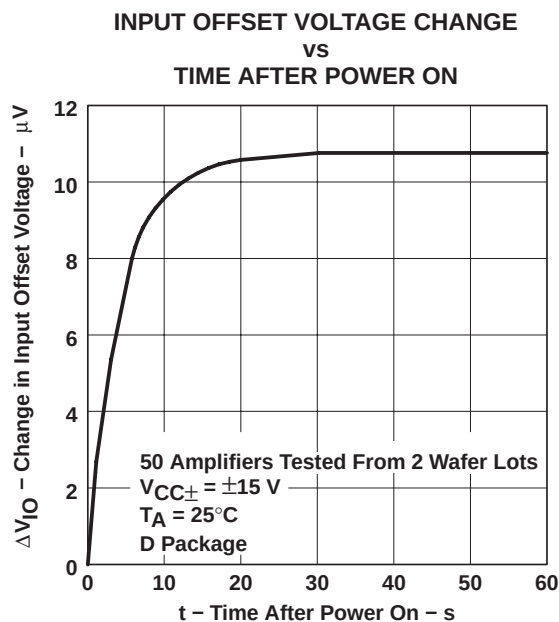


Figure 7

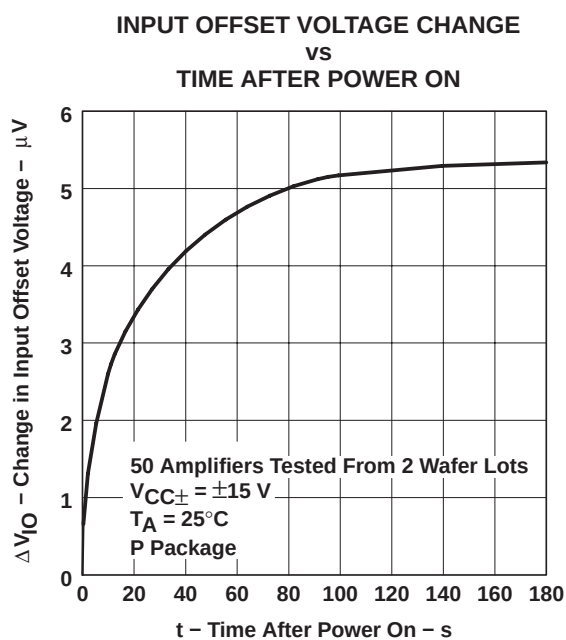


Figure 8

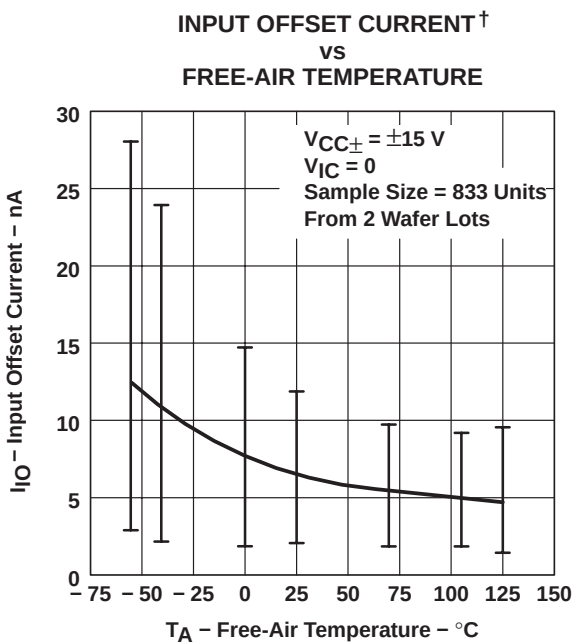


Figure 9

<sup>†</sup> Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

## TYPICAL CHARACTERISTICS

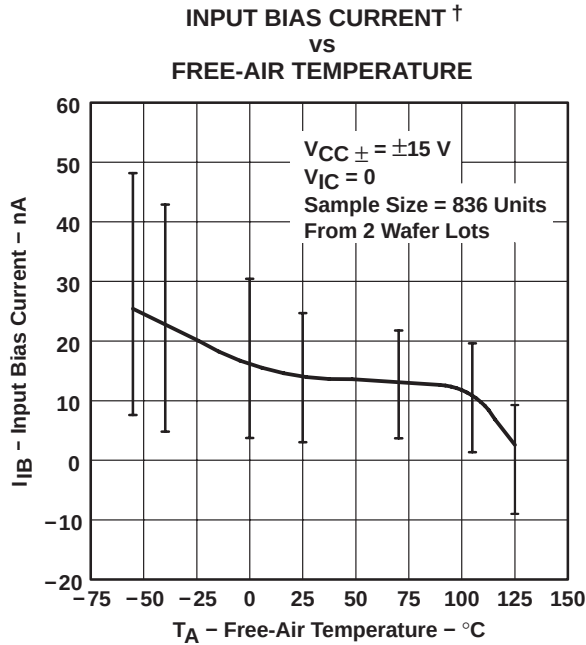


Figure 10

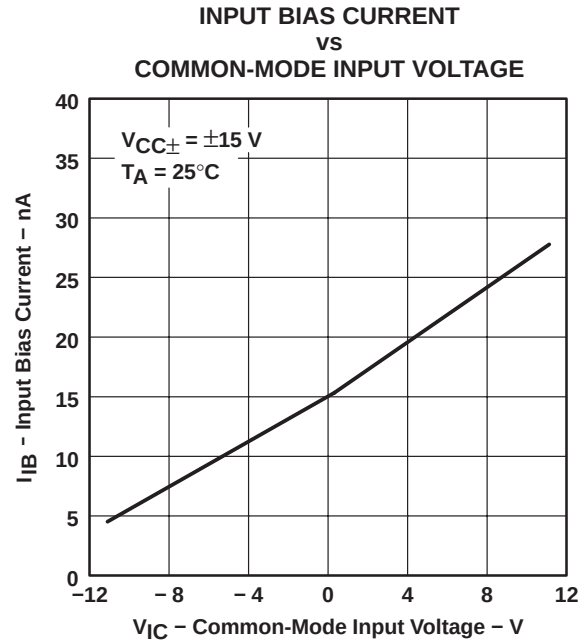


Figure 11

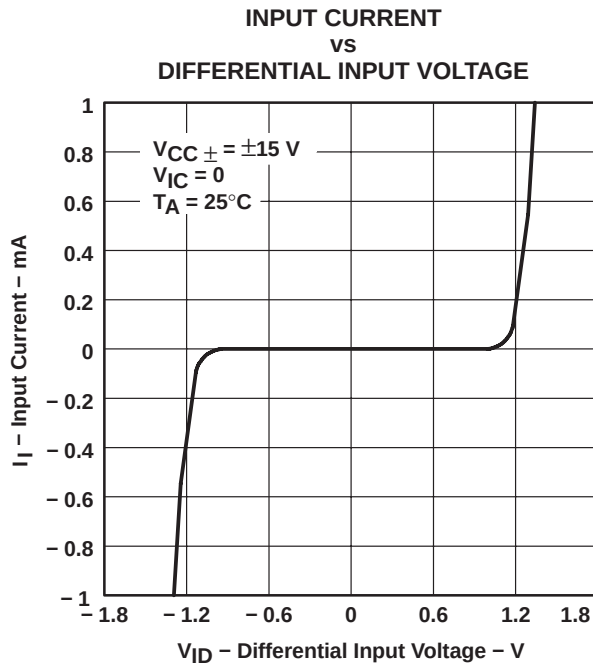


Figure 12

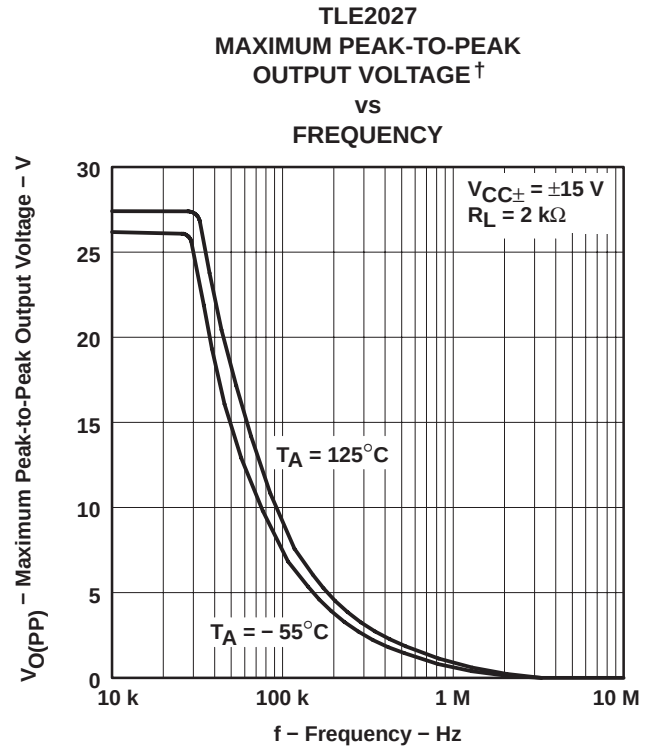


Figure 13

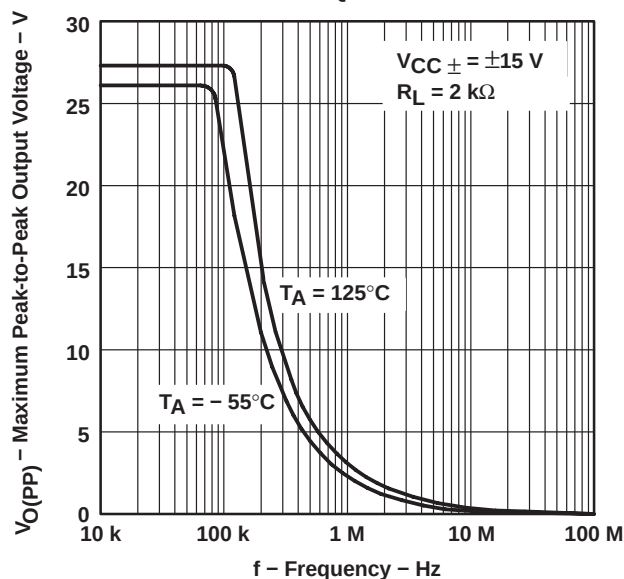
<sup>†</sup> Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

# TLE2027-Q1, TLE2037-Q1, TLE2027A-Q1, TLE2037A-Q1 EXCALIBUR LOW-NOISE HIGH-SPEED PRECISION OPERATIONAL AMPLIFIERS

SGL 02571 OCT 09 13:2000 RELEASED BY TEXAS INSTRUMENTS CORPORATION OCTOBER 2006

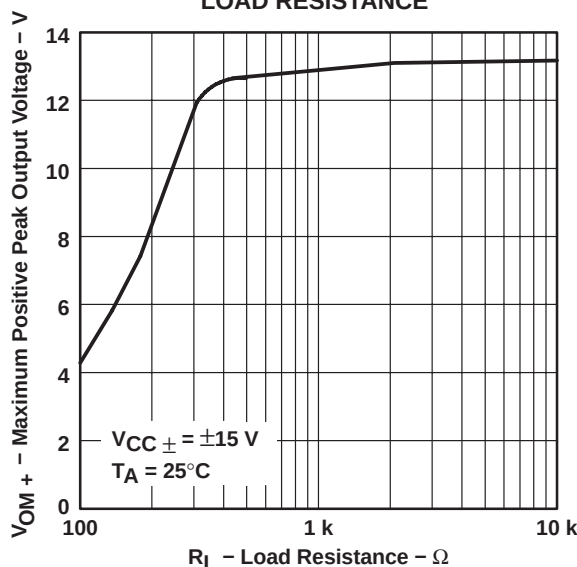
## TYPICAL CHARACTERISTICS

**TLE2037**  
MAXIMUM PEAK-TO-PEAK  
OUTPUT VOLTAGE<sup>†</sup>  
VS  
FREQUENCY



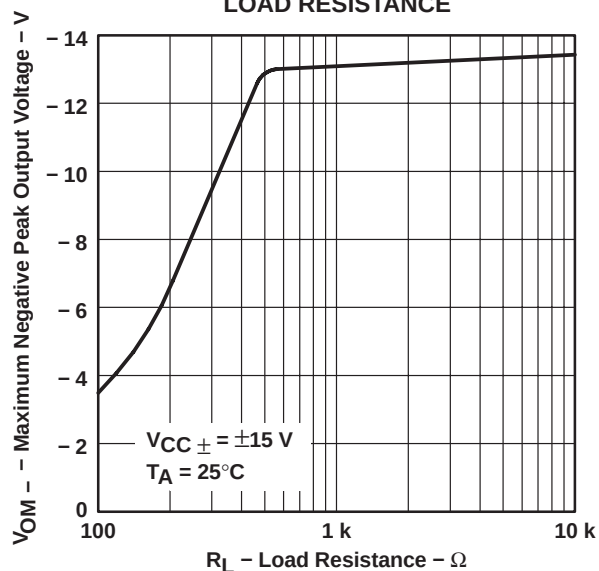
**Figure 14**

MAXIMUM POSITIVE PEAK  
OUTPUT VOLTAGE  
VS  
LOAD RESISTANCE



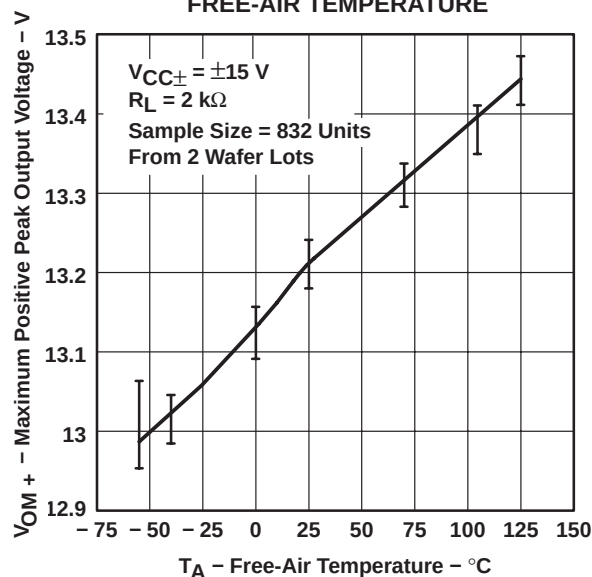
**Figure 15**

MAXIMUM NEGATIVE PEAK  
OUTPUT VOLTAGE  
VS  
LOAD RESISTANCE



**Figure 16**

MAXIMUM POSITIVE PEAK  
OUTPUT VOLTAGE<sup>†</sup>  
VS  
FREE-AIR TEMPERATURE



**Figure 17**

<sup>†</sup> Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

## TYPICAL CHARACTERISTICS

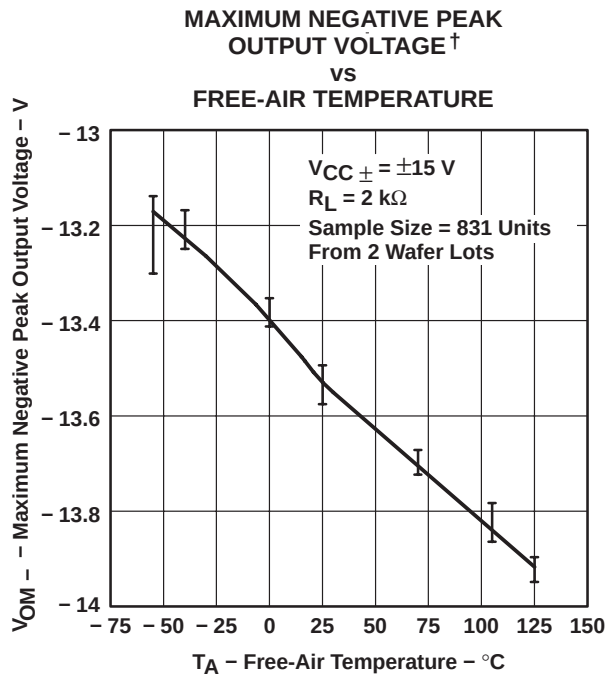


Figure 18

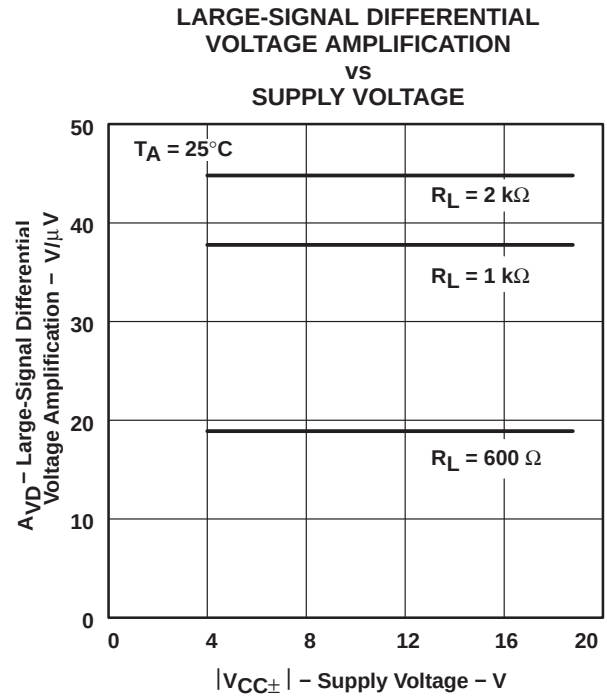


Figure 19

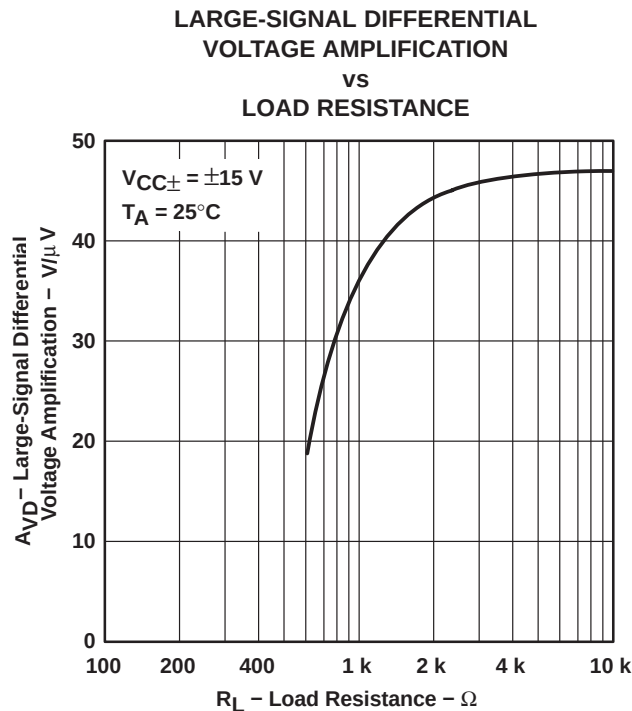


Figure 20

<sup>†</sup> Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

TLE2027-Q1, TLE2037-Q1, TLE2027A-Q1, TLE2037A-Q1  
EXCALIBUR LOW-NOISE HIGH-SPEED  
PRECISION OPERATIONAL AMPLIFIERS

SGLS225 OCT 09 13:20:00 RELEASED OCTOBER 2006

TYPICAL CHARACTERISTICS

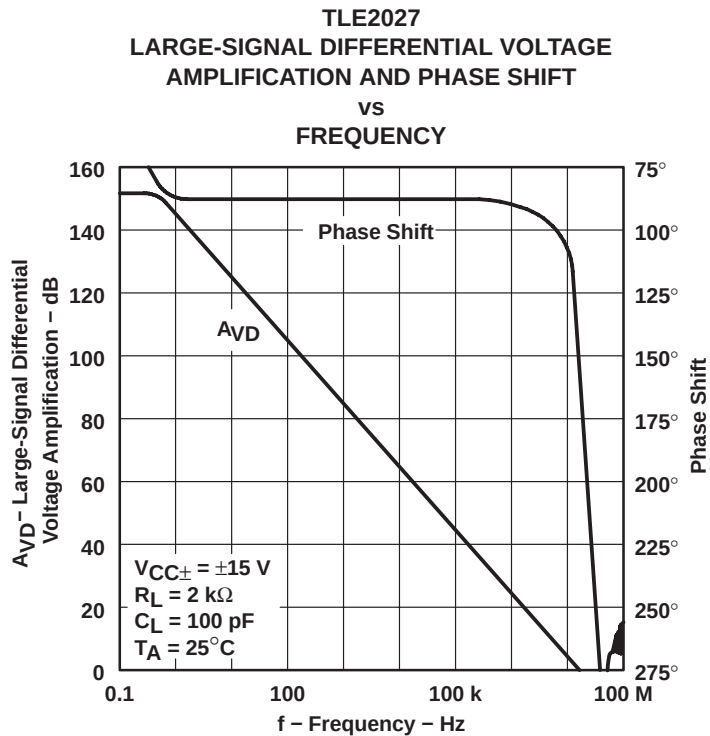


Figure 21

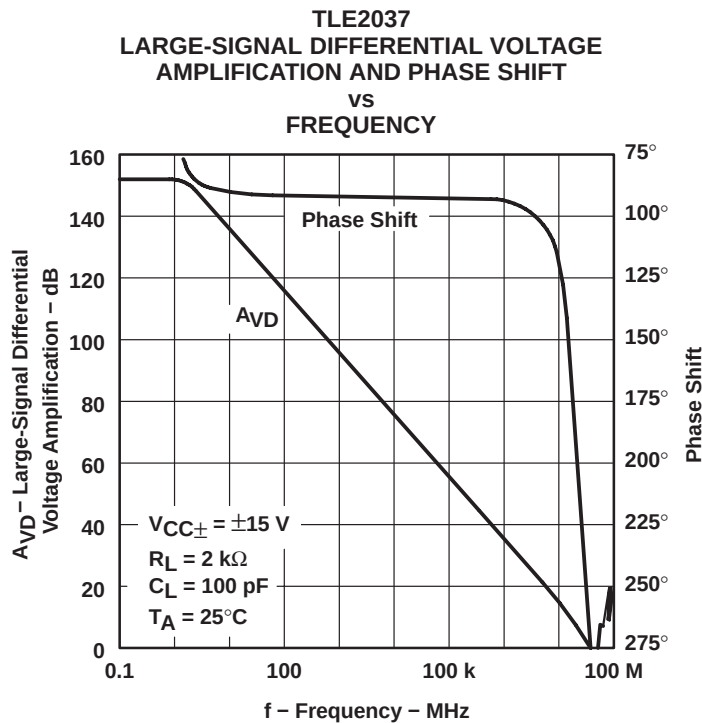


Figure 22



## TYPICAL CHARACTERISTICS

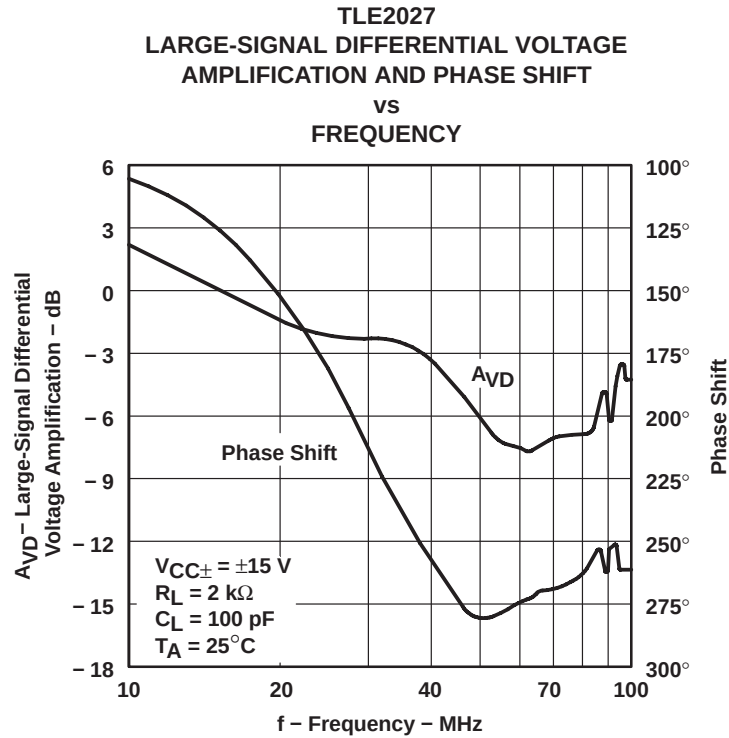


Figure 23

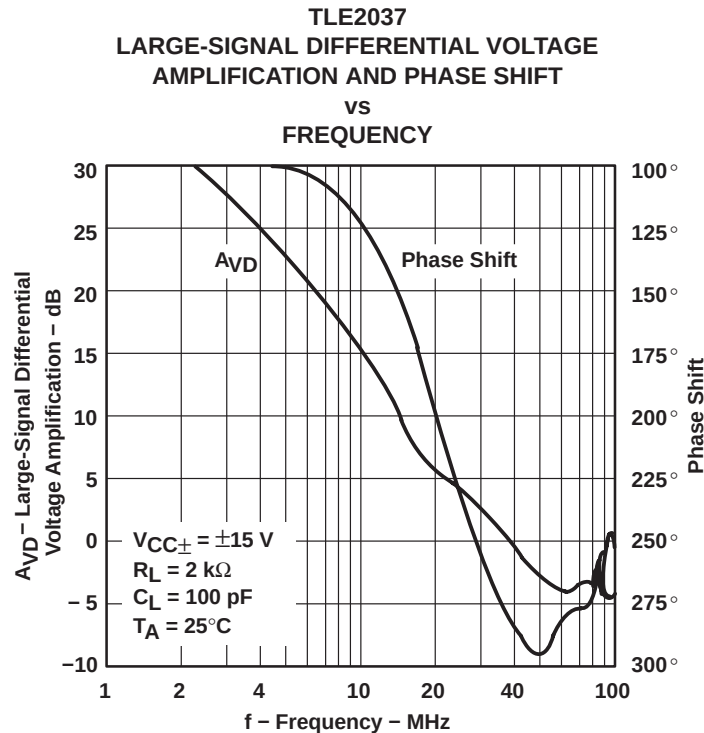


Figure 24

TLE2027-Q1, TLE2037-Q1, TLE2027A-Q1, TLE2037A-Q1  
EXCALIBUR LOW-NOISE HIGH-SPEED  
PRECISION OPERATIONAL AMPLIFIERS

SGLS257 OCT 09 2006 RELEASED OCTOBER 2006

TYPICAL CHARACTERISTICS

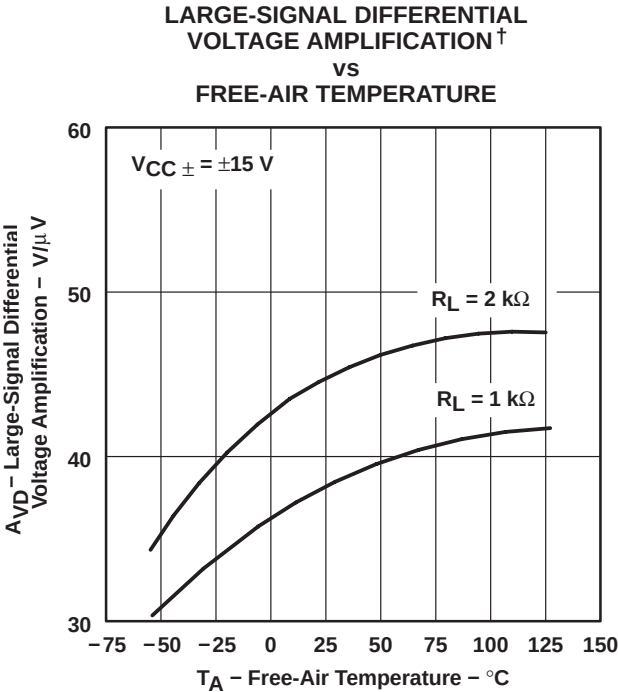
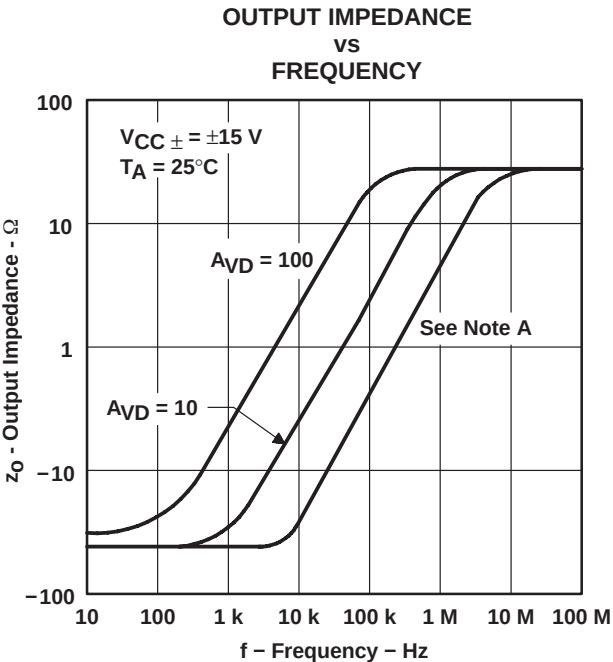


Figure 25



NOTE A: For this curve, the TLE2027 is  $A_{VD} = 1$  and the TLE2037 is  $A_{VD} = 5$ .

Figure 26

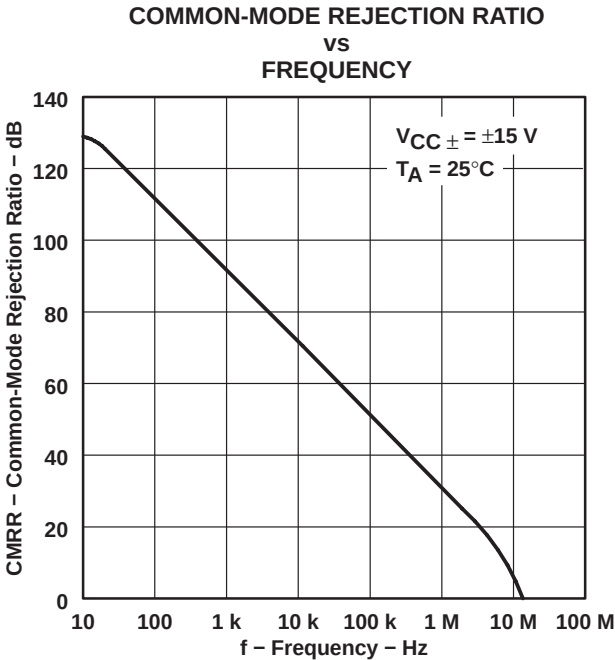


Figure 27

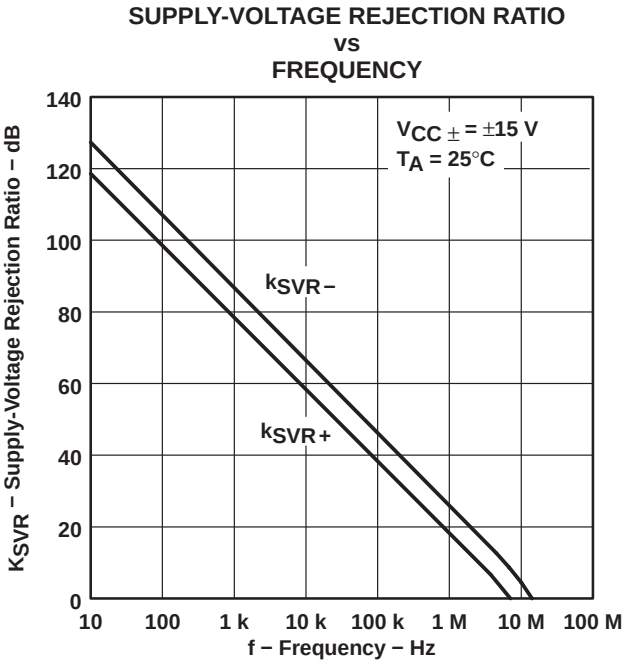


Figure 28

<sup>†</sup> Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.



## TYPICAL CHARACTERISTICS

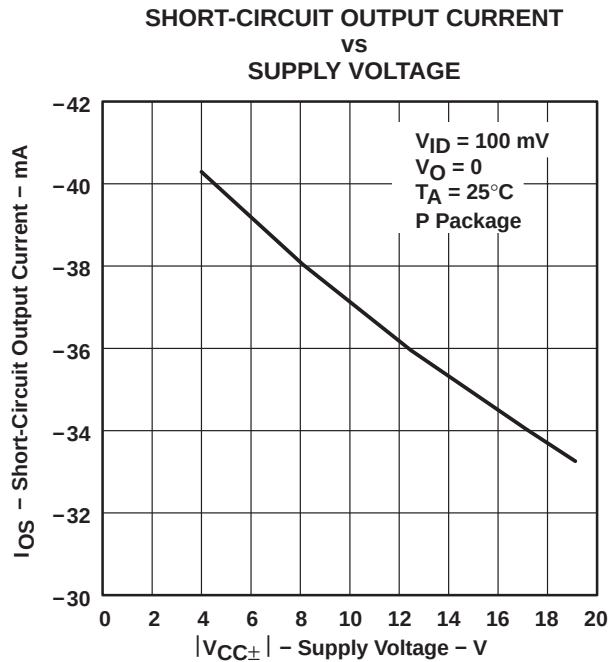


Figure 29

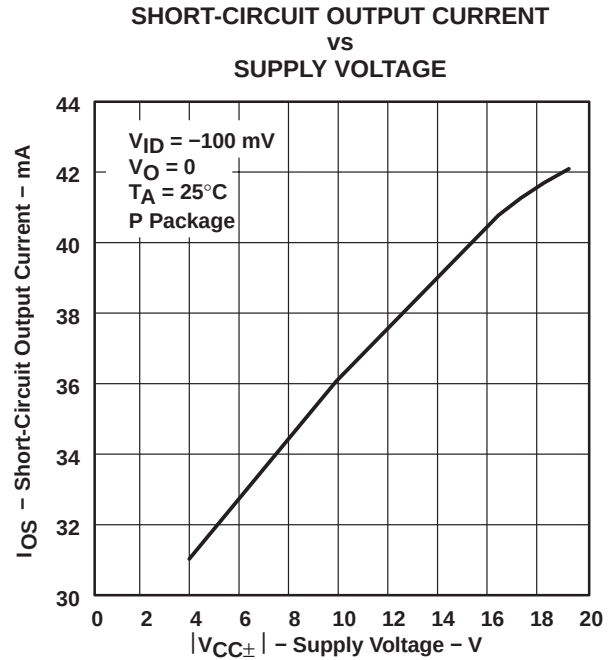


Figure 30

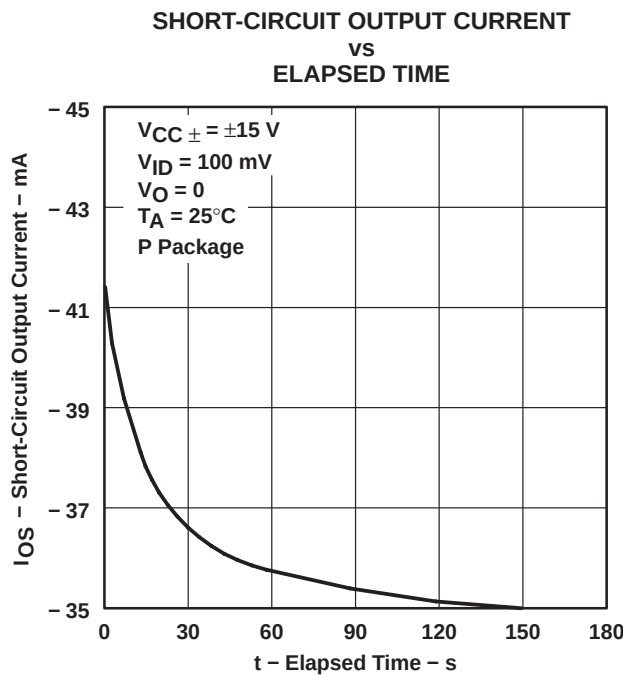


Figure 31

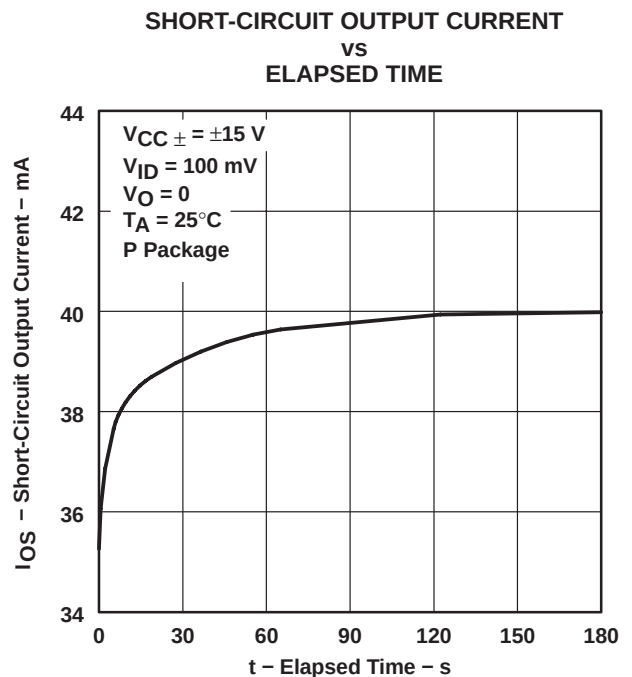


Figure 32

# TLE2027-Q1, TLE2037-Q1, TLE2027A-Q1, TLE2037A-Q1 EXCALIBUR LOW-NOISE HIGH-SPEED PRECISION OPERATIONAL AMPLIFIERS

SGLS 2571 OCT 09 13 2006 RELEASED TO THE PUBLIC

## TYPICAL CHARACTERISTICS

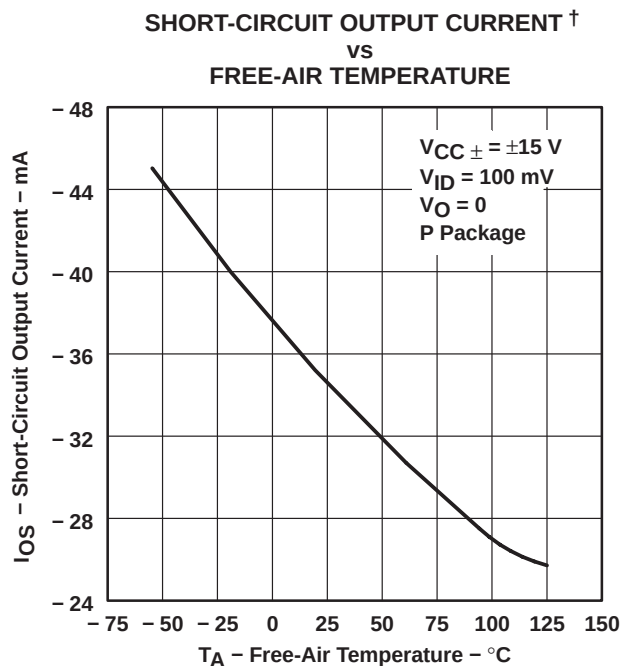


Figure 33

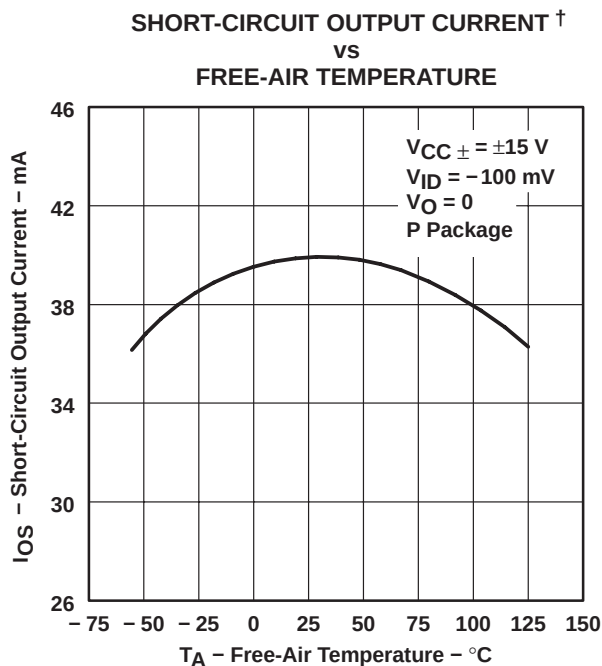


Figure 34

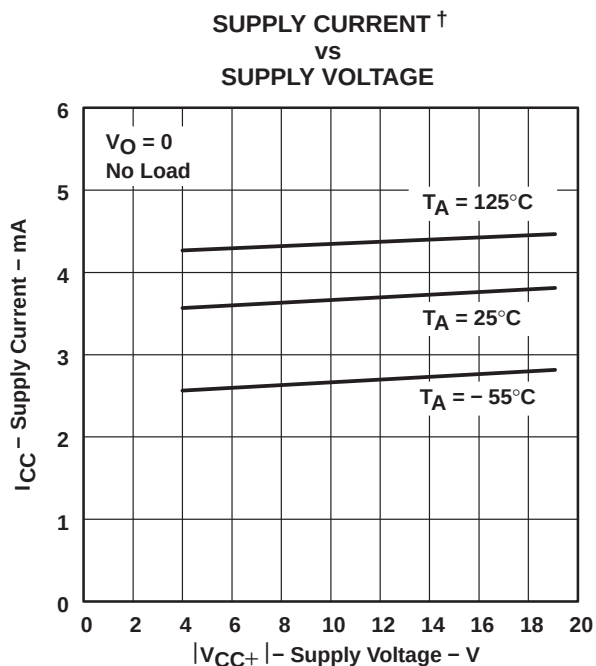


Figure 35

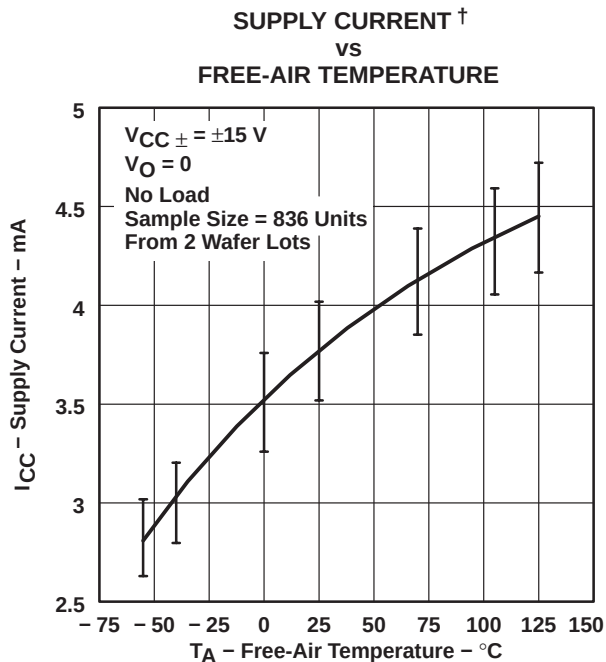


Figure 36

<sup>†</sup> Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

## TYPICAL CHARACTERISTICS

TLE2027  
VOLTAGE-FOLLOWER  
SMALL-SIGNAL  
PULSE RESPONSE

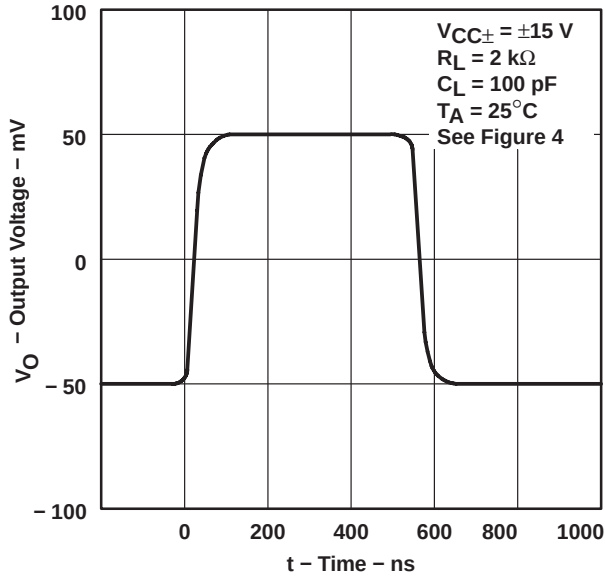


Figure 37

TLE2027  
VOLTAGE-FOLLOWER  
LARGE-SIGNAL  
PULSE RESPONSE

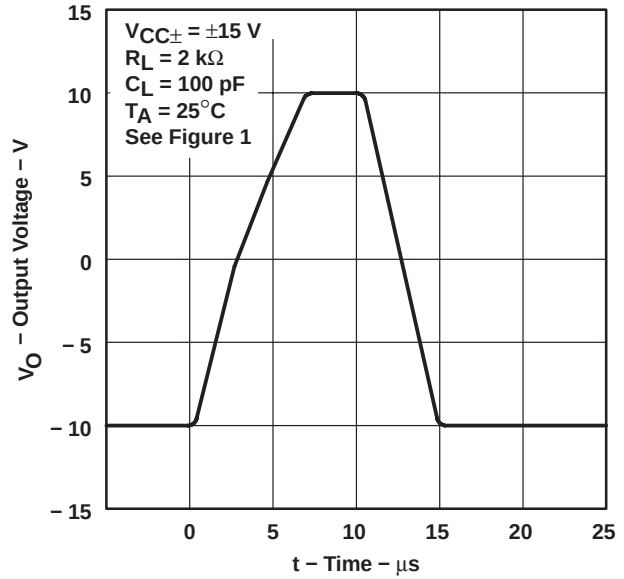


Figure 38

TLE2037  
VOLTAGE-FOLLOWER  
SMALL-SIGNAL  
PULSE RESPONSE

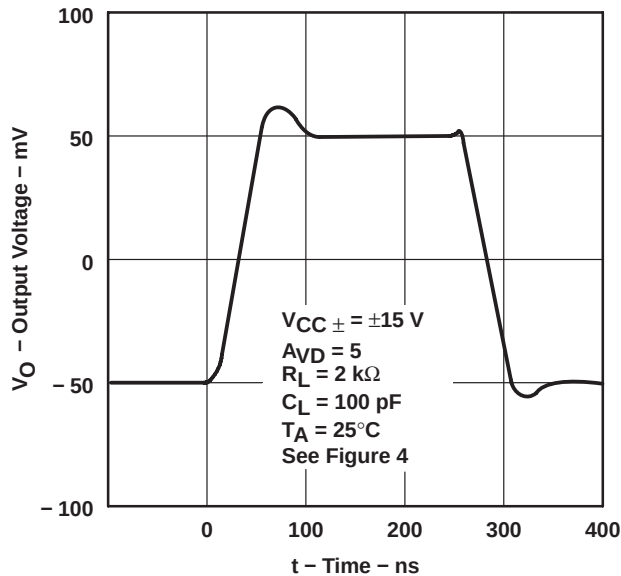


Figure 39

TLE2037  
VOLTAGE-FOLLOWER  
LARGE-SIGNAL  
PULSE RESPONSE

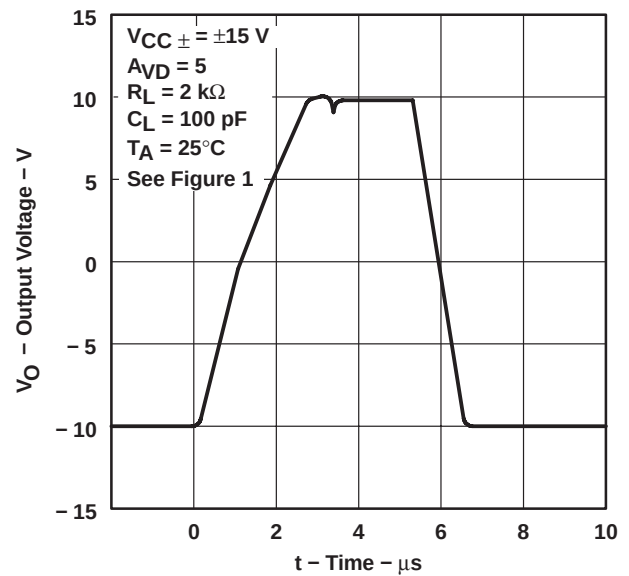


Figure 40

TLE2027-Q1, TLE2037-Q1, TLE2027A-Q1, TLE2037A-Q1  
EXCALIBUR LOW-NOISE HIGH-SPEED  
PRECISION OPERATIONAL AMPLIFIERS

SGLS 257 OCT 09 2006 RELEASED TO THE PUBLIC

TYPICAL CHARACTERISTICS

EQUIVALENT INPUT NOISE VOLTAGE  
VS  
FREQUENCY

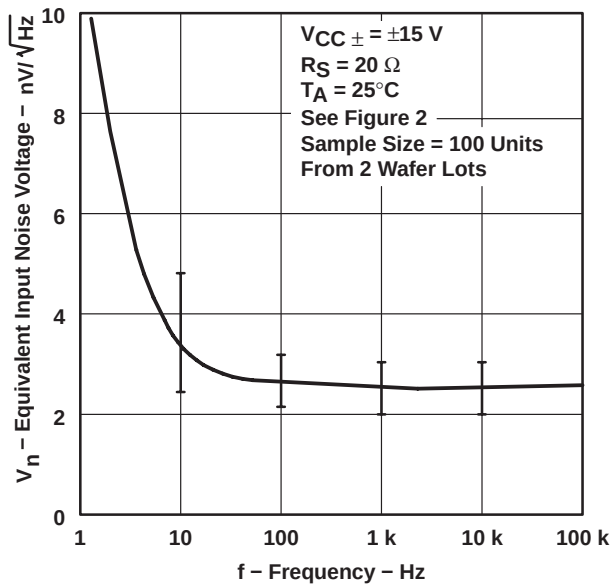


Figure 41

NOISE VOLTAGE  
(REFERRED TO INPUT)  
OVER A 10-SECOND INTERVAL

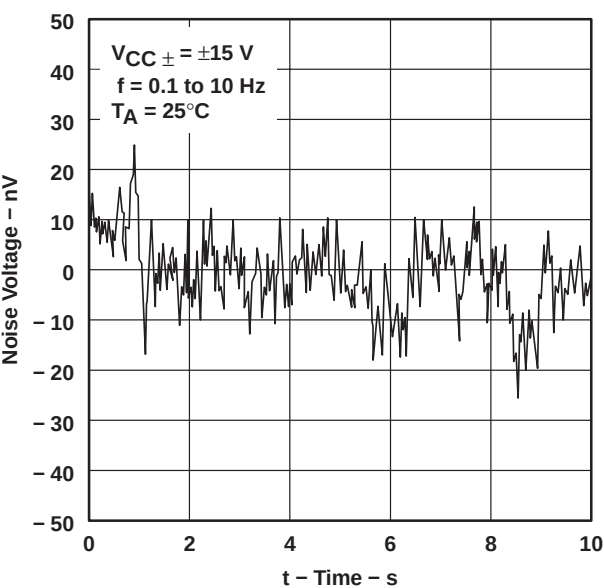


Figure 42

TLE2027  
UNITY-GAIN BANDWIDTH  
VS  
SUPPLY VOLTAGE

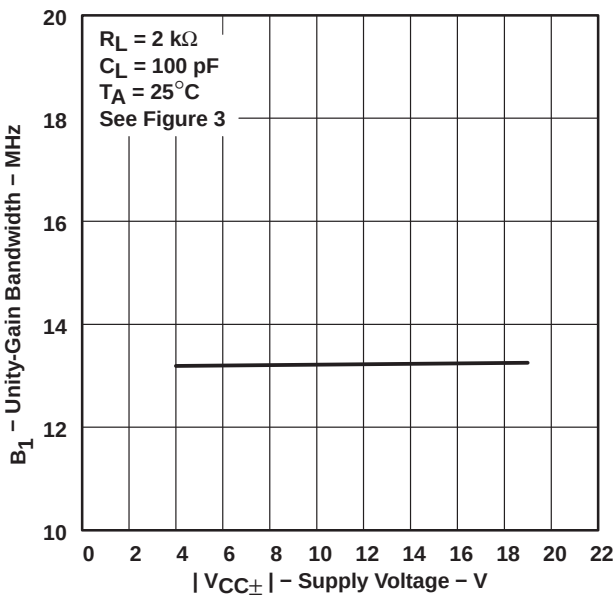


Figure 43

TLE2037  
GAIN-BANDWIDTH PRODUCT  
VS  
SUPPLY VOLTAGE

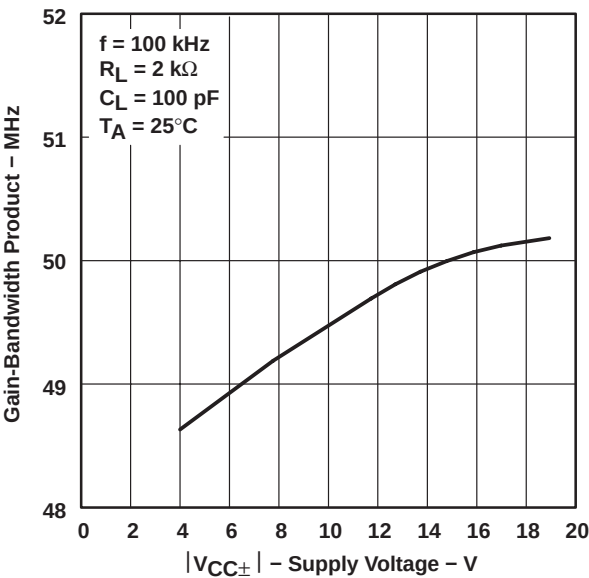


Figure 44

## TYPICAL CHARACTERISTICS

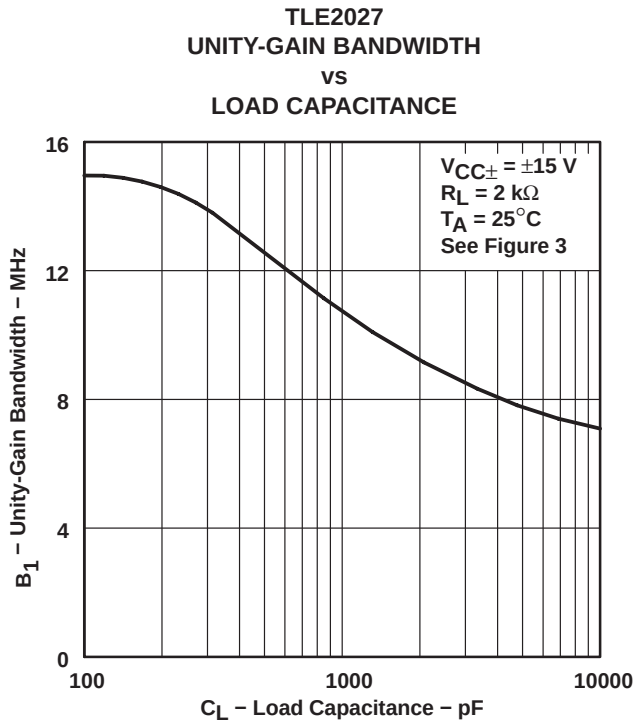


Figure 45

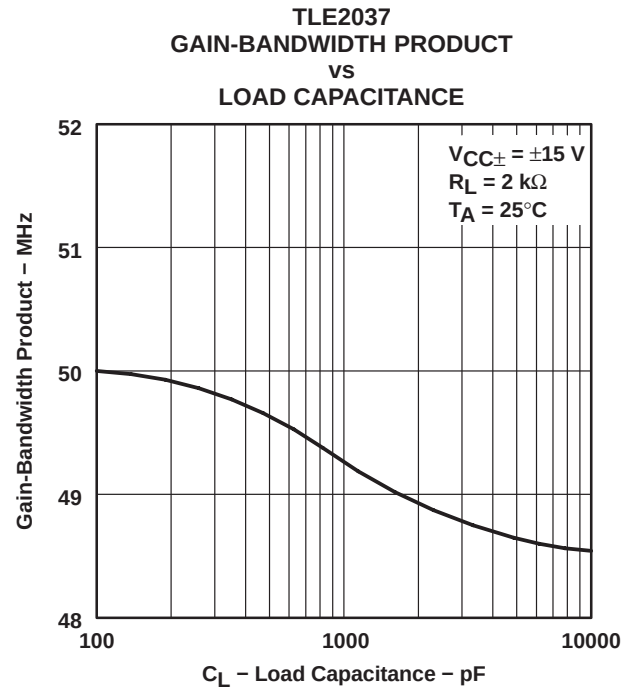


Figure 46

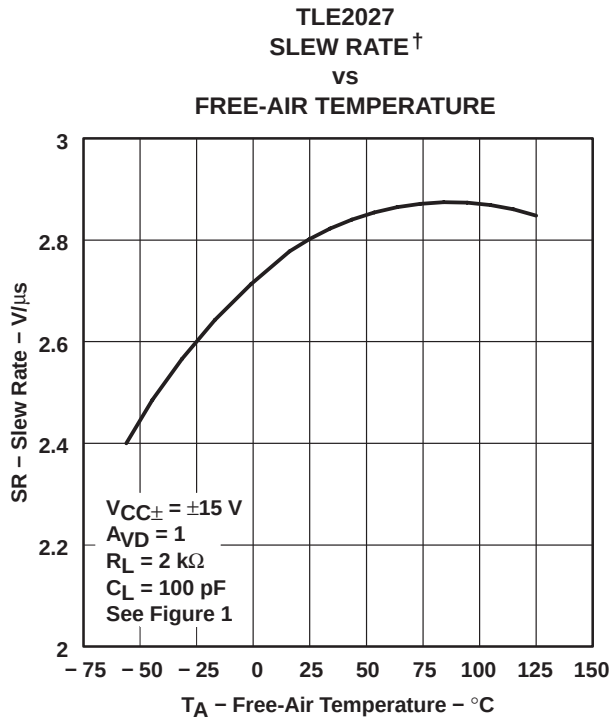


Figure 47

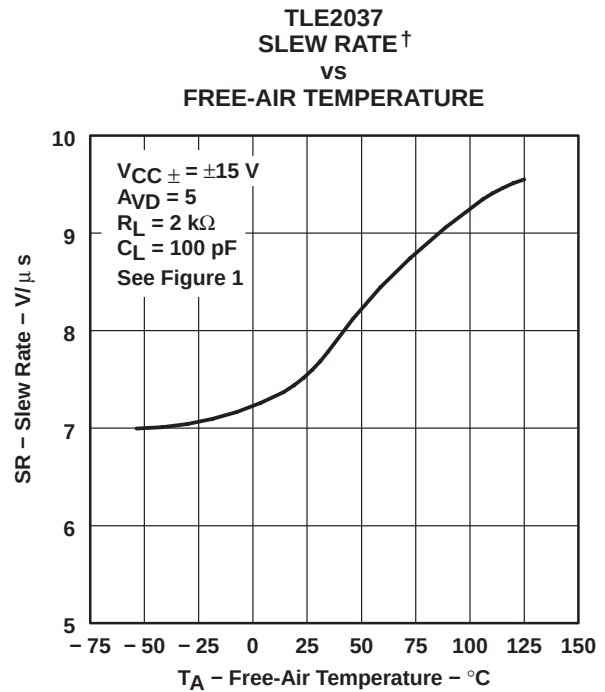


Figure 48

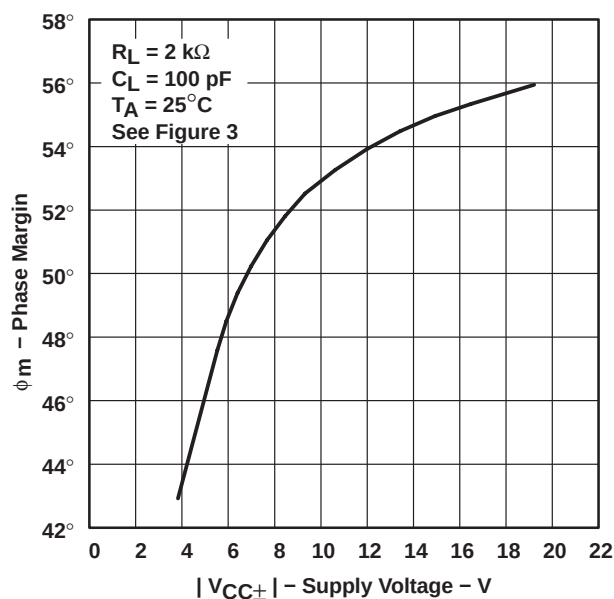
<sup>†</sup> Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

# TLE2027-Q1, TLE2037-Q1, TLE2027A-Q1, TLE2037A-Q1 EXCALIBUR LOW-NOISE HIGH-SPEED PRECISION OPERATIONAL AMPLIFIERS

SGLS227 "TLE2027-Q1, TLE2037-Q1, TLE2027A-Q1, TLE2037A-Q1" OCTOBER 2006

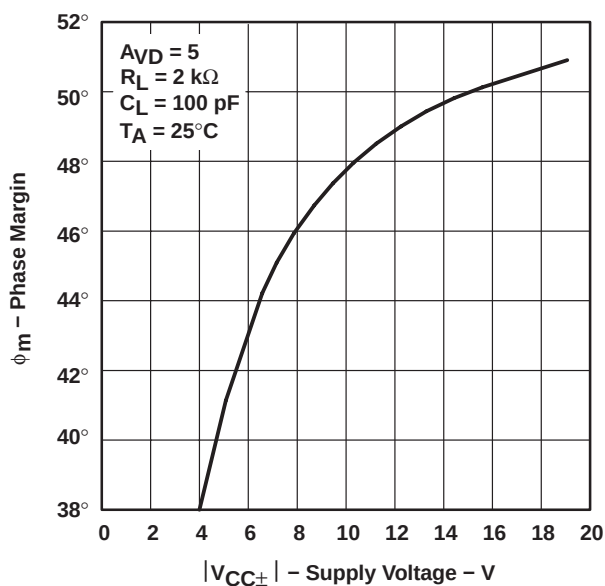
## TYPICAL CHARACTERISTICS

**TLE2027  
PHASE MARGIN  
vs  
SUPPLY VOLTAGE**



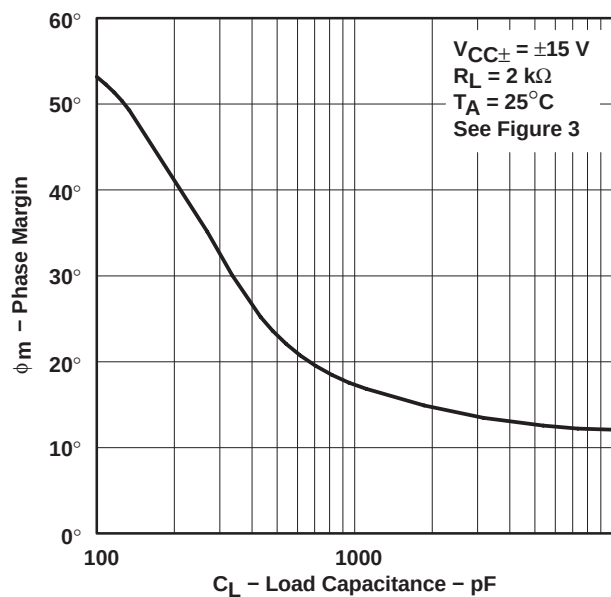
**Figure 49**

**TLE2037  
PHASE MARGIN  
vs  
SUPPLY VOLTAGE**



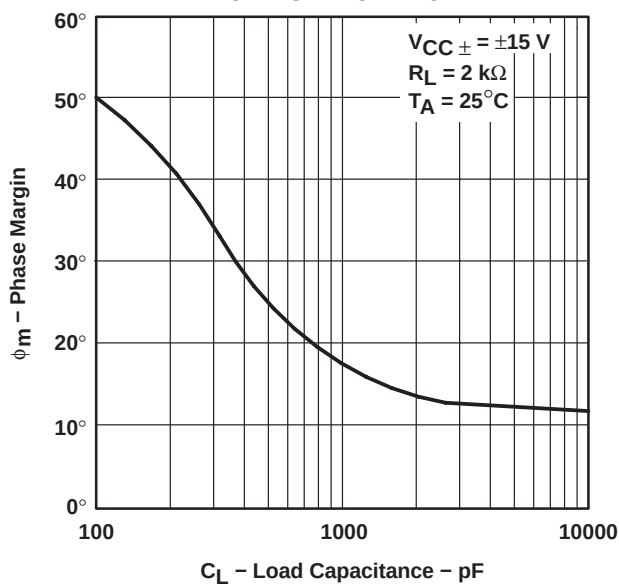
**Figure 50**

**TLE2027  
PHASE MARGIN  
vs  
LOAD CAPACITANCE**



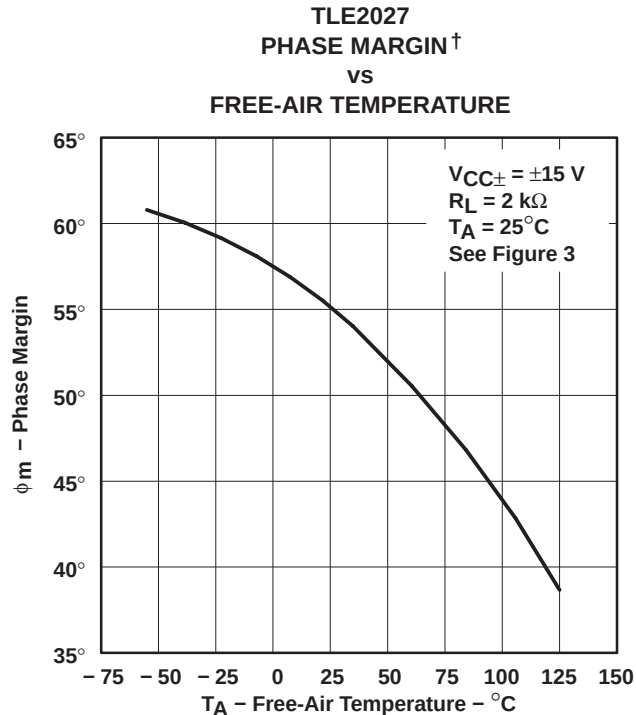
**Figure 51**

**TLE2037  
PHASE MARGIN  
vs  
LOAD CAPACITANCE**

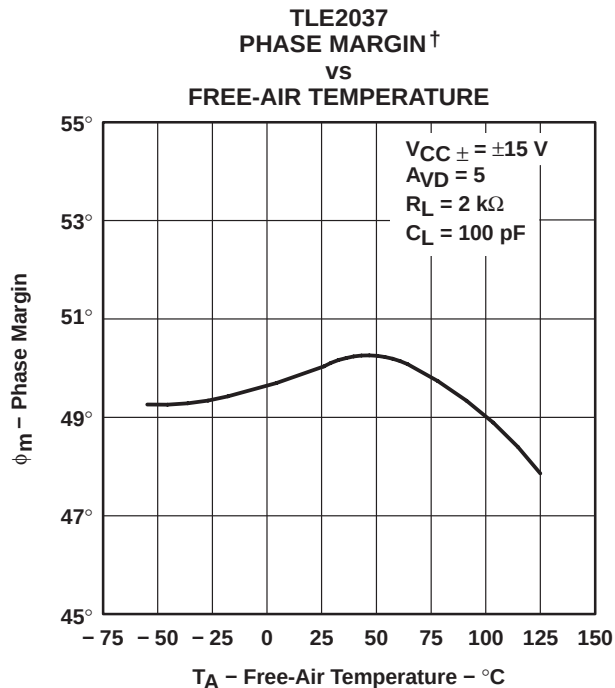


**Figure 52**

## TYPICAL CHARACTERISTICS



**Figure 53**



**Figure 54**

<sup>†</sup> Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

# TLE2027-Q1, TLE2037-Q1, TLE2027A-Q1, TLE2037A-Q1 EXCALIBUR LOW-NOISE HIGH-SPEED PRECISION OPERATIONAL AMPLIFIERS

SGLS226 OCT 1993 2000 REVISIONS OCTOBER 2006

## APPLICATION INFORMATION

### input offset voltage nulling

The TLE2027 and TLE2037 series offers external null pins that can be used to further reduce the input offset voltage. The circuits of Figure 55 can be connected as shown if the feature is desired. If external nulling is not needed, the null pins may be left disconnected.

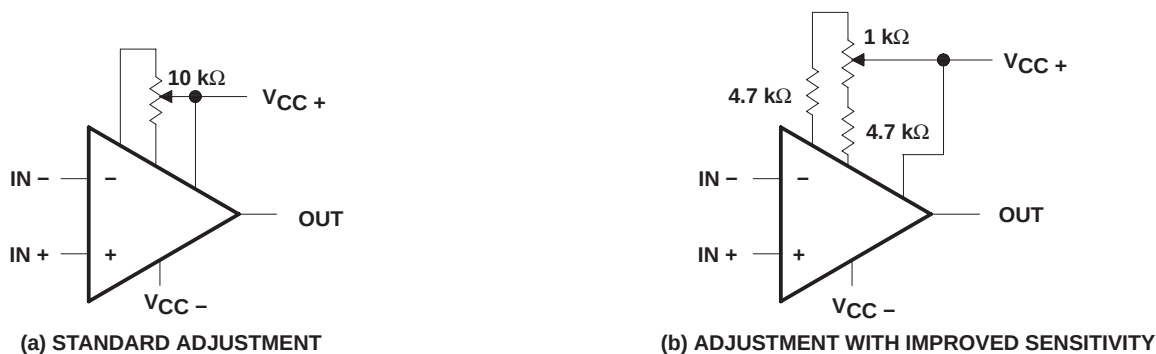


Figure 55. Input Offset Voltage Nulling Circuits

### voltage-follower applications

The TLE2027 circuitry includes input-protection diodes to limit the voltage across the input transistors; however, no provision is made in the circuit to limit the current if these diodes are forward biased. This condition can occur when the device is operated in the voltage-follower configuration and driven with a fast, large-signal pulse. It is recommended that a feedback resistor be used to limit the current to a maximum of 1 mA to prevent degradation of the device. Also, this feedback resistor forms a pole with the input capacitance of the device. For feedback resistor values greater than 10 kΩ, this pole degrades the amplifier phase margin. This problem can be alleviated by adding a capacitor (20 pF to 50 pF) in parallel with the feedback resistor (see Figure 56).

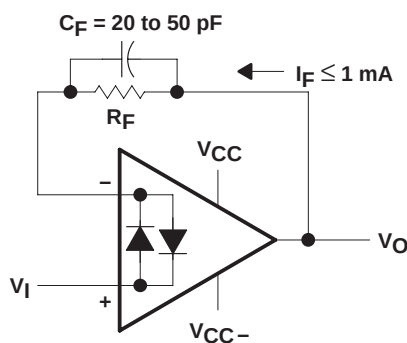


Figure 56. Voltage Follower



## APPLICATION INFORMATION

### macromodel information

Macromodel information provided was derived using Microsim *Parts*™, the model generation software used with Microsim *PSpice*™. The Boyle macromodel (see Note 6) and subcircuit in Figure 57, Figure 58, and Figure 59 were generated using the TLE20x7 typical electrical and operating characteristics at 25°C. Using this information, output simulations of the following key parameters can be generated to a tolerance of 20% (in most cases):

- Maximum positive output voltage swing
- Maximum negative output voltage swing
- Slew rate
- Quiescent power dissipation
- Input bias current
- Open-loop voltage amplification
- Gain-bandwidth product
- Common-mode rejection ratio
- Phase margin
- DC output resistance
- AC output resistance
- Short-circuit output current limit

NOTE 6: G. R. Boyle, B. M. Cohn, D. O. Pederson, and J. E. Solomon, "Macromodeling of Integrated Circuit Operational Amplifiers", IEEE Journal of Solid-State Circuits, SC-9, 353 (1974).

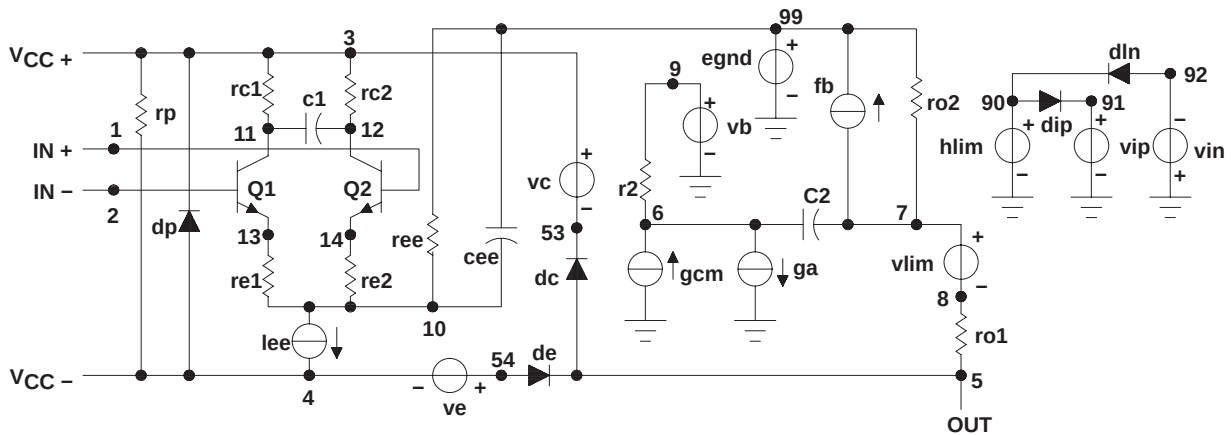


Figure 57. Boyle Macromodel

# TLE2027-Q1, TLE2037-Q1, TLE2027A-Q1, TLE2037A-Q1 EXCALIBUR LOW-NOISE HIGH-SPEED PRECISION OPERATIONAL AMPLIFIERS

SGLS 5245 "TLE2027-Q1, TLE2037-Q1, TLE2027A-Q1, TLE2037A-Q1" REVISION 10 OCTOBER 2006

## APPLICATION INFORMATION

### macromodel information (continued)

```
.subckt TLE2027 1 2 3 4 5
*
c1      11  12  4.003E-12
c2      6   7  20.00E-12
dc      5  53  dz
de      54  5  dz
dlp     90  91  dz
dln     92  90  dx
dp      4   3  dz
egnd    99  0  poly(2) (3,0)
(4,0) 0 5 .5
fb      7  99  poly(5) vb vc
ve vlp vln 0 954.8E6 -1E9 1E9 1E9
-1E9
ga      6   0  11  12
2.062E-3
gcm     0   6  10  99
531.3E-12
iee     10  4  dc 56.01E-6
hlim    90  0  vlim 1K
q1      11  2  13 qx
q2      12  1  14 qx
r2      6   9  100.0E3
rc1     3  11  530.5
rc2     3  12  530.5
re1     13  10 -393.2
re2     14  10 -393.2
ree     10  99 3.571E6
ro1     8   5  25
ro2     7  99  25
rp      3   4  8.013E3
vb      9   0  dc 0
vc      3  53  dc 2.400
ve      54  4  dc 2.100
vlim    7   8  dc 0
vlp     91  0  dc 40
vln     0  92  dc 40
.modeldx D(Is=800.0E-18)
.modelqx NPN(Is=800.0E-18
Bf=7.000E3)
.ends
```

Figure 58. TLE2027 Macromodel Subcircuit

```
.subckt TLE2037 1 2 3 4 5
*
c1      11  12  4.003E-12
c2      6   7  7.500E-12
dc      5  53  dz
de      54  5  dz
dlp     90  91  dz
dln     92  90  dx
dp      4   3  dz
egnd    99  0  poly(2) (3,0)
(4,0) 0 .5 .5
fb      7  99  poly(5) vb vc
ve vip vln 0 923.4E6 A800E6
800E6 800E6 A800E6
ga      6   0  11  12 2.121E-3
gcm     0   6  10  99 597.7E-12
iee     10  4  dc 56.26E-6
hlim    90  0  vlim 1K
q1      11  2  13 qx
q2      12  1  14 qz
r2      6   9  100.0E3
rc1     3  11  471.5
rc2     3  12  471.5
re1     13  10 A448
re2     14  10 A448
ree     10  99 3.555E6
ro1     8   5  25
ro2     7  99  25
rp      3   4  8.013E3
vb      9   0  dc 0
vc      3  53  dc 2.400
ve      54  4  dc 2.100
vlim    7   8  dc 0
vlp     91  0  dc 40
vln     0  92  dc 40
.model  dxD(Is=800.0E-18)
.model  qxNPN(Is=800.0E-18
Bf=7.031E3)
.ends
```

Figure 59. TLE2037 Macromodel Subcircuit



**PACKAGING INFORMATION**

| Orderable Device | Status <sup>(1)</sup> | Package Type | Package Drawing | Pins | Package Qty | Eco Plan <sup>(2)</sup> | Lead/Ball Finish | MSL Peak Temp <sup>(3)</sup> |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| TLE2037AQDRG4Q1  | ACTIVE                | SOIC         | D               | 8    | 2500        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| TLE2037AQDRQ1    | ACTIVE                | SOIC         | D               | 8    | 2500        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| TLE2037QDRG4Q1   | ACTIVE                | SOIC         | D               | 8    | 2500        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| TLE2037QDRQ1     | ACTIVE                | SOIC         | D               | 8    | 2500        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |

<sup>(1)</sup> The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

<sup>(2)</sup> Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

<sup>(3)</sup> MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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**OTHER QUALIFIED VERSIONS OF TLE2037-Q1, TLE2037A-Q1 :**

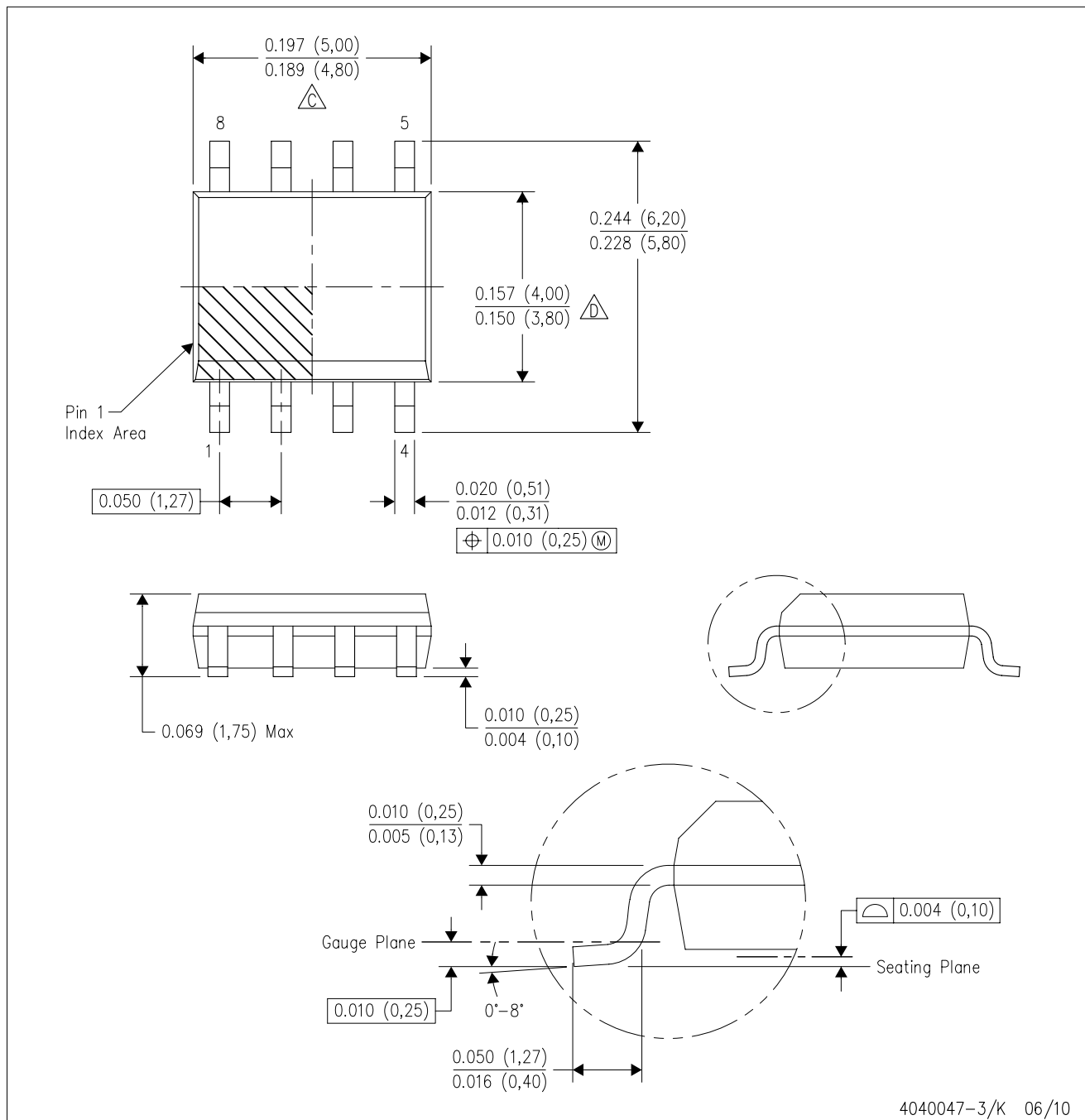
- Catalog: [TLE2037](#), [TLE2037A](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

D (R-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE

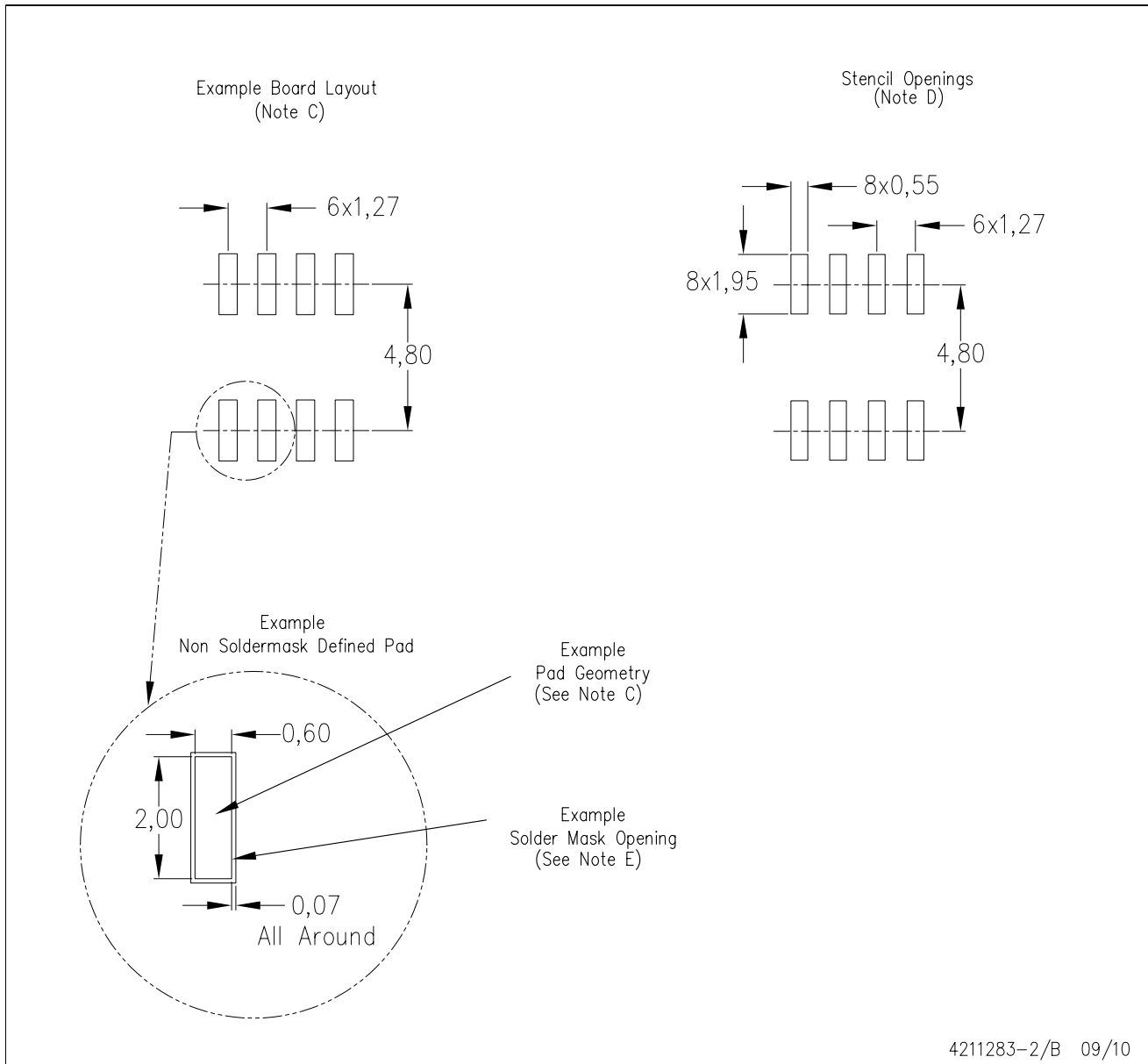


NOTES:

- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- $\triangle C$  Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 (0,15) per end.
- $\triangle D$  Body width does not include interlead flash. Interlead flash shall not exceed .017 (0,43) per side.
- E. Reference JEDEC MS-012 variation AA.

D (R-PDSO-G8)

PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Publication IPC-7351 is recommended for alternate designs.
  - D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
  - E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

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